DMEL

BAND-PASS
BAND-REJECT & HIGH-PASS

VARIABLE FILTER

MODEL 315-A(R)

OPERATING AND MAINTENANCE MANUAL

KROHN-HITE CORPORATION
580 Massachusetts Ave., Cambridge, Mass., 02139, U.S.A.

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SERIAL NO. 350

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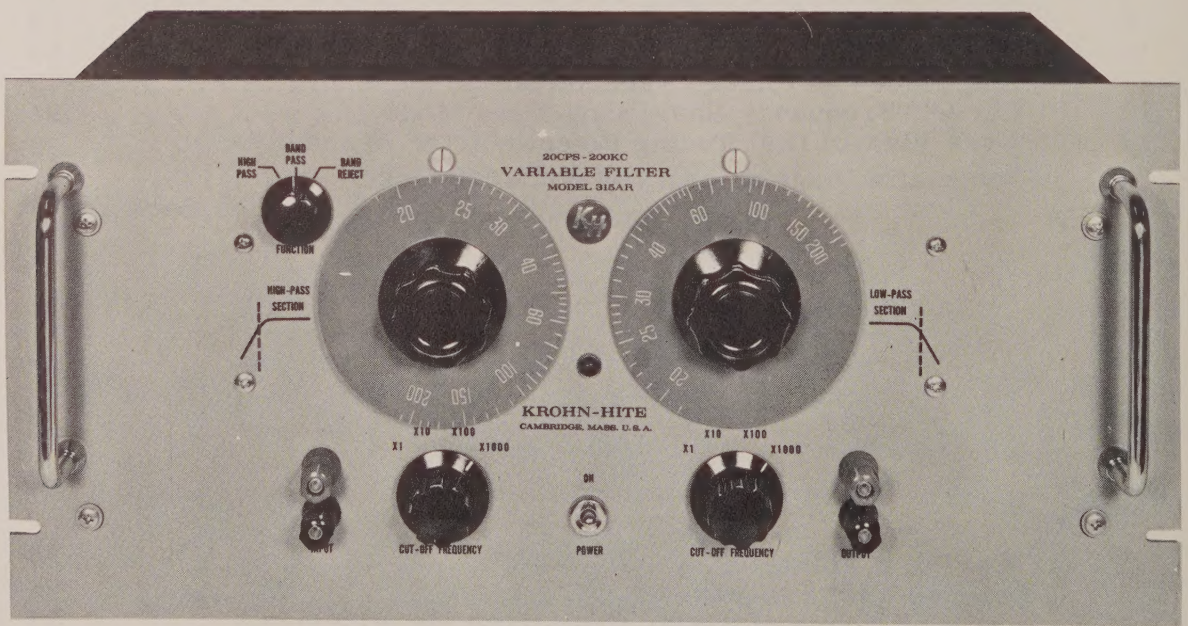
Model 315-A



Model 315-AR

Figure 1. Model 315-A(R) Variable Electronic Filter

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 315-A(R) Filter, as shown in Figure 1, is a variable electronic filter that operates in frequencies ranging from 20 cps to 200kc and is capable of being operated in any one of three functional modes; the band-pass mode, the band-reject mode, or the high-pass mode. Each mode of operation can be selected by means of a front panel FUNCTION switch.

As shown in the Simplified Schematic Diagram, Figure 2, the Filter consists basically of an input amplifier, a variable high-pass section, and a variable low-pass section. When operated in the band-pass mode, the high-pass and low-pass sections are connected in series. In the band-reject mode, the high-pass and low-pass sections are connected in parallel. When operated in the high-pass mode, the low-pass section is by-passed and the high-pass section only is used alone. The overall gain of the Filter in the pass-band of any mode of operation is unity (0 db).

The cut-off frequency of both the high-pass and low-pass sections, when operated in the band-pass or band-reject mode, is independently adjustable from 20 cps to 200kc. For high-pass operation the cut-off frequency of the high-pass section only is variable over the 20 cps to 200kc frequency range. Operation in the band-pass or band-reject modes permits passage or rejection of bands with frequencies of variable width within the 20 cps to 200kc range. Operation in the high-pass mode permits passage of frequencies higher than any selected frequency within the 20 cps to 200kc range, up to the upper 3 db point of approximately 3 megacycles. In the band-reject mode, the Filter passes all frequencies, except the selected reject band, from the lower 3 db point of approximately 1 cps to the upper 3 db point of approximately 1 megacycle.

1.2 FILTER RESPONSE

The flexibility of adjustment of bandwidth for each of the three modes of operation is illustrated in Figure 3. Band-pass operation for four different bandwidths is illustrated by curves A, B, C, and D (solid lines). Band-reject operation for a single bandwidth with a frequency separation factor of 10,000 is illustrated by curve E (dotted lines). To avoid confusion, only this single example of band-reject operation is shown. Note that the characteristic curve for band-reject operation is essentially a mirror image of a curve for band-pass operation. High-pass operation can be represented by the left-hand portion of curves A or B when either curve is shifted to the right until it intercepts the -3 db point at unity normalized frequency. In this case the abscissa should be labeled f/f_H. As indicated by Figure 3, the mid-band

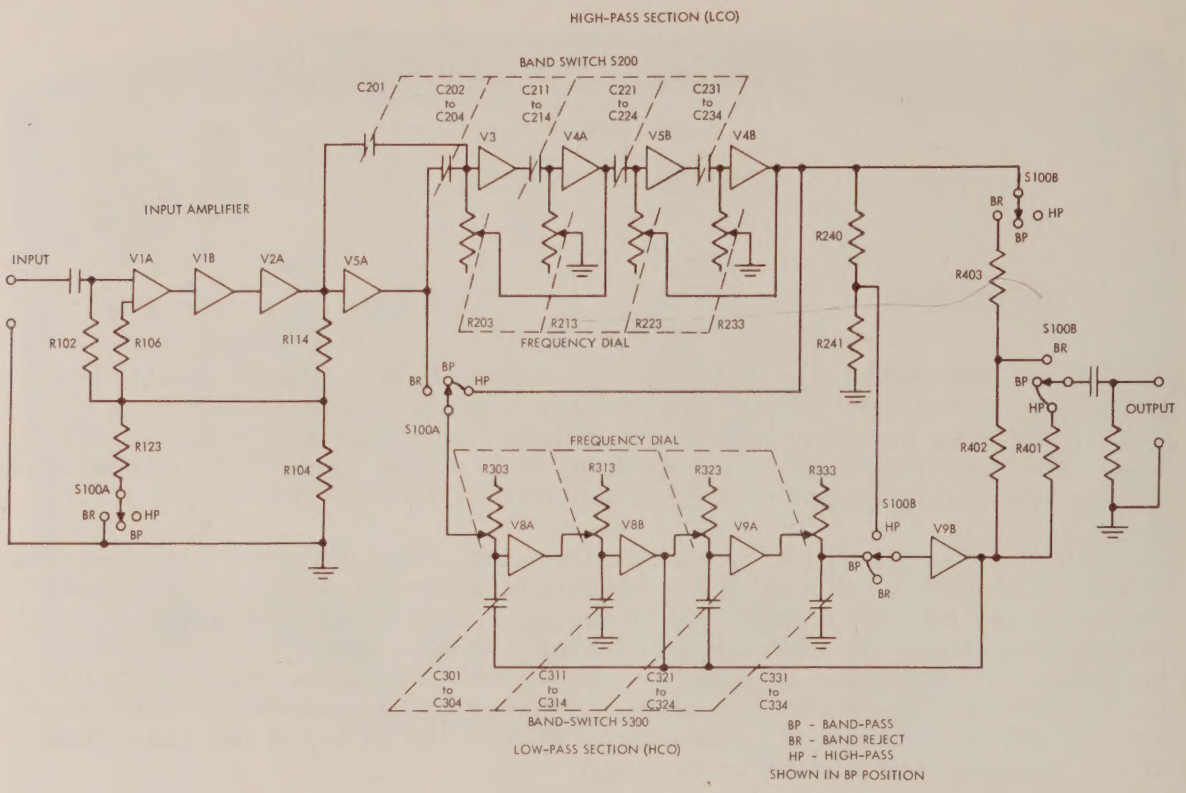


Figure 2. Simplified Schematic Diagram

gain varies for different frequency separation factors (and hence different bandwidths). The attenuation slope, (below -3 db point) on the other hand, is 24 db per octave for all curves.

The minimum width of the pass-band is obtained by setting the two cut-off frequencies equal. As illustrated in Figure 4, the insertion loss is 6 db, and the -3 db points (half-power points) occur at 0.77 and 1.3 times the mid-band frequency. The dotted lines illustrate the 24 db/octave asymptotes intercepting the mid-band frequency or zero-db point.

The response for the minimum width of band rejection is also shown in Figure 4. This response is essentially a sharp null with -3 db points at 0.5 and 2.0 times the mid-band frequency. The null is obtained by setting the high and low cut-off frequencies at a factor of approximately 2 from the desired null frequency. The null frequency can be set at any point between 100 cps and 50 kc. The peaking factor of the Filter contributes to the sharpness of the minimum reject band. In contrast, a balanced parallel T-filter with no peaking circuit would locate the -3 db points at about 0.25 and 4 times the null frequency and a flatter slope would be obtained above -25 db.

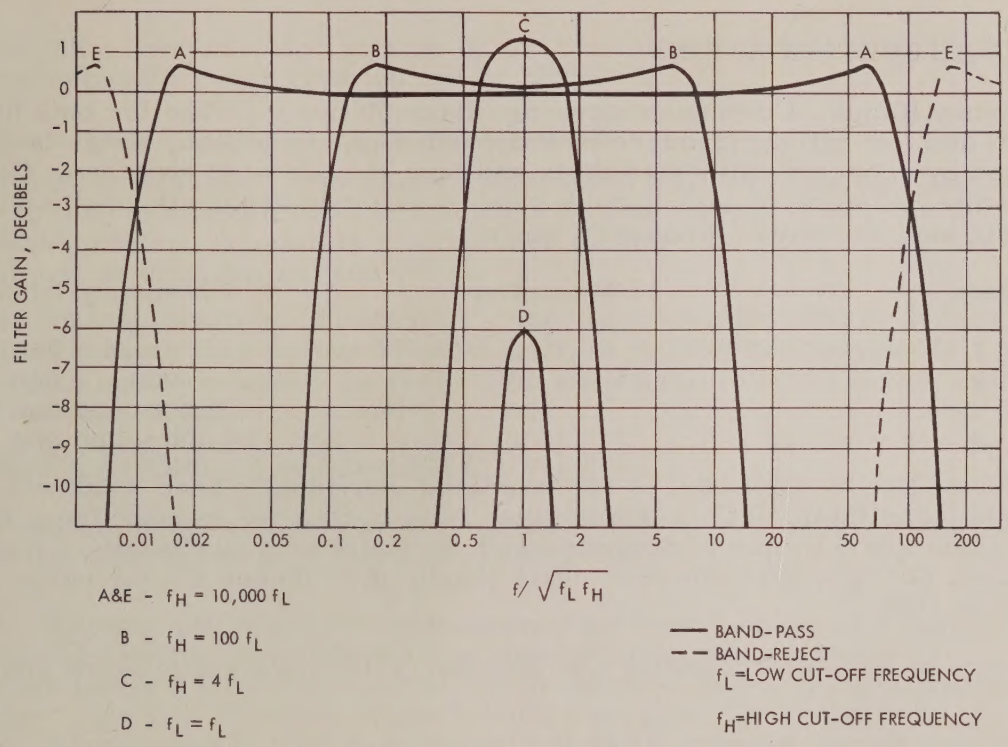


Figure 3. Normalized Filter Response

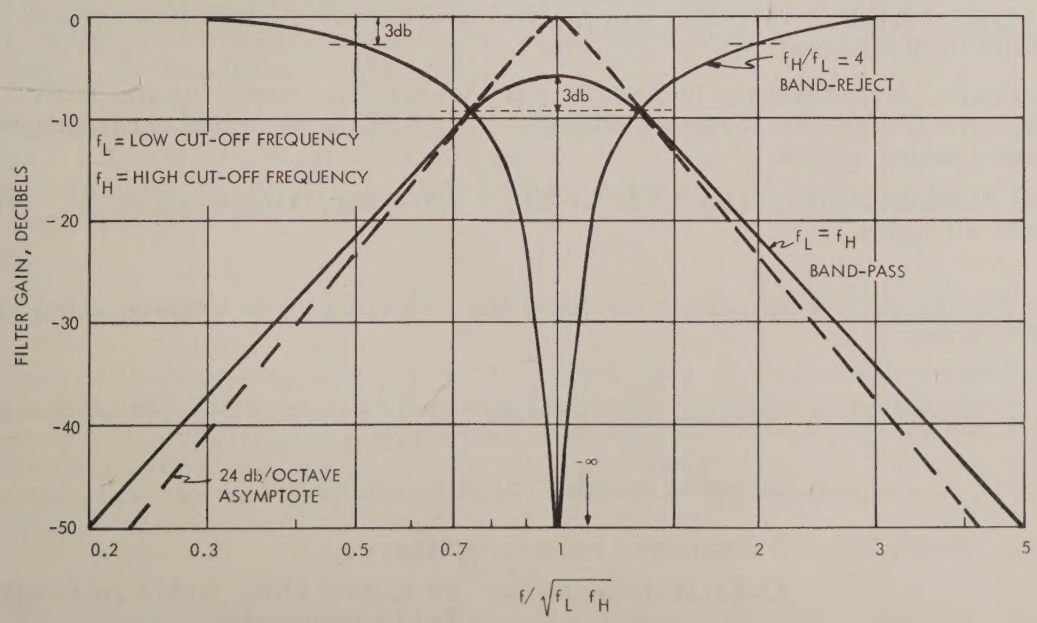


Figure 4. Narrow Band Operation

1.3 TECHNICAL SUMMARY

GENERAL SPECIFICATIONS

Frequency Range: Continuous coverage from 20 cps to 200kc for both high cut-off and low cut-off frequencies independently. Frequency range is covered by separate calibrated dials and four-decade band switches. Center frequency and width of pass band in band-pass mode are continuously adjustable over the entire frequency range.

Band	Multiplier	Frequency (cps)
1	1	20 - 200
2	10	200 - 2,000
3	100	2,000 - 20,000
4	1000	20,000 - 200,000

Frequency Dials: Each dial is engraved and individually hand-calibrated with a single logarithmic scale reading directly in cycles per second, from 19 to 210. Dials are 4 inches in diameter with an effective scale length of 8 inches per band, giving a total effective scale length of 32 inches for the range of 20 cps to 200kc.

Accuracy of Cut-off Frequency Calibration: ±10% (±5% available on special order).

Attenuation Slope: Nominal 24 db per octave each side of pass-band with peaking factor to reduce attenuation at cut-off frequencies.

Maximum Attenuation: Greater than 60 db.

Controls: LOW CUT-OFF FREQUENCY dial and multiplier switch. HIGH CUT-OFF FREQUENCY dial and multiplier switch. FUNCTION switch. POWER OFF-ON switch.

Terminals: Front panel, two multi-purpose binding posts for the INPUT and two for the OUTPUT. Rear of chassis, two BNC type connectors, one for input and one for output.

Power Requirements: 105 - 125 or 210 - 250 volts, single phase; 50 - 400 cycles; 50 watts.

Fuse Protection: 1 ampere slow-blow for 115 volts, 1/2 ampere slow-blow for 230 volts.

Form: Model 315A Overall dimensions: 12-1/2 inches wide, 8 inches high, 8-1/2 inches deep.

Shipping weight: 21 lbs, 19 lbs net.

Model 315-AR (Standard rack mounting) :

Overall dimensions: 19 inches side, 8-3/4 inches high, 7-1/2 inches deep.

Shipping weight: 24 lbs, 21 lbs net.

SPECIFICATIONS AS BAND-PASS FILTER

Bandwidth: Continuously variable up to the maximum width covering the entire frequency range from 20 cps to 200kc.

Insertion Loss: Zero db ± 1 db in pass band.

Input Characteristics: Impedance: Approximately 6 megohms in parallel with 50 μμf. Maximum input amplitude: 5 volts rms up to 200 kc, decreasing to approximately 1 volt at 500 kc and 0.5 volt at 1 megacycle. Maximum dc component: 400 volts.

Output Characteristics: Impedance: Approximately 500 ohms. Maximum power: 2.5 volts rms across 500 ohms, or 12 milliwatts. Internally generated hum and noise: Less than 0.5 millivolt. (Slightly higher for 400-cps operation.)

SPECIFICATIONS AS BAND-REJECT FILTER

Bandwidth: Sharp null or continuously variable up to maximum width covering the entire range from 20 cps to 200kc.

Null: A sharp null filter at any frequency between 100 cps and 50kc is obtained by setting the high and low cut-off frequencies a factor of approximately 2 from the desired null frequency. The resulting null is sharper than that obtained with a balanced parallel "T" null filter.

Insertion Loss: Zero db ± 1 db for frequencies outside the rejection region with 3 db points at approximately 1 cps and 1 megacycle.

Input Characteristics: Impedance: Approximately 6 megohms in parallel with 50 μμf. Maximum input amplitude: 3 volts rms up to 200 kc, decreasing to approximately 0.5 volt at 500 kc and 0.25 volt at 1 megacycle. Maximum dc component: 400 volts.

Output Characteristics: Impedance: Approximately 1,500 ohms. Maximum power: 1.5 volts rms across 1,500 ohms, or 1.5 milliwatts. Internally generated hum and noise: Less than 1.0 millivolt. (Slightly higher for 400-cps operation.)

SPECIFICATIONS AS HIGH-PASS FILTER

Same specifications as band-pass filter operation, except the low-pass section is not used. The cut-off frequency is continuously adjustable from 20 cps to 200kc, and the upper 3 db point is at approximately 3 megacycles. Maximum input amplitude decreases above 200kc to approximately 1 volt at 500kc, 0.5 volt at 1 megacycle, and 0.25 volt at 2 megacycles.

NOTE

For a detailed definition of specifications refer to Section 5.1.

SECTION 2

OPERATION

2.1 INTRODUCTION

The Filter is adjusted and checked carefully before shipment to insure that it meets all specifications. It is then aged and again tested to be sure that it is ready for use. The Filter is shipped complete, and after unpacking, is ready to be turned on and used.

Unpack the Filter carefully and inspect it for damage that may have occurred during shipment. Check the case for damage, and check for loose sub-assemblies and parts. Make sure electron tubes are properly seated in place. Check all front panel controls for freedom of operation. The recommended operating procedure is described below.

The rms voltage of the input signal should not exceed 5 volts for operation in either the band-pass or high-pass modes, and 3 volts for operation in the band-reject mode. Above 200kc refer to the specifications in paragraph 1.3 for the maximum input voltage. The dc component of the input signal should not exceed 400 volts for operation in any mode.

2.2 FRONT PANEL CONTROLS

The front panel of the Filter includes two identical frequency dials and associated multiplier switches used to set cut-off frequencies, a FUNCTION switch used to select the mode of operation, a power on-off switch and indicator light: two multi-purpose binding posts for the input signal and two for the output signal.

Each frequency dial is engraved and individually hand calibrated with a single logarithmic scale reading directly in cycles per second from 19 to 210. The dials are four inches in diameter with an effective scale length of approximately eight inches per band, giving a total effective scale length of approximately 32 inches for the 20 cps to 200kc range. In the band-pass mode of operation, as indicated by a diagram engraved on the front panel at the side of each frequency dial, the left-hand dial (HIGH-PASS SECTION) and band multiplier switch select the low cut-off frequency while the right-hand dial (LOW-PASS SECTION) and multiplier switch select the high cut-off frequency. In band-reject operation the left-hand dial and switch select the high cut-off frequency while the right-hand dial and switch select the low cut-off frequency. In high-pass operation, only the left-hand dial is used.

Each of the two multiplier switches has four positions, covering the frequency ranges as follows:

Band	Multiplier	Frequency (cps)
1	1	20 - 200
2	10	200 - 2,000
3	100	2,000 - 20,000
4	1000	20,000 - 200,000

2.3 OPERATION

To operate the Filter, proceed as follows:

a. Make appropriate power connections as described in Section 2.5.

b. Make appropriate connections to INPUT and OUTPUT terminals of filter.

c. Turn FUNCTION switch to desired mode of operation.

d. Set cut-off frequencies by means of the band multiplier switches (CUT-OFF FREQUENCY) and the frequency dials.

e. Turn POWER switch to ON.

NOTE

For operation in the band-pass mode, the left-hand band multiplier switch and frequency dial are used to select the low cut-off frequency, and the right-hand controls select the high cut-off frequency. For operation in the band-reject mode, the right-hand controls select the low cut-off frequency and the left-hand controls select the high cut-off frequency. For operation in the high-pass mode, the cut-off frequency is selected by the left-hand controls only.

With FUNCTION switch on BAND PASS, the minimum pass-band is obtained by setting the high cut-off frequency equal to the low cut-off frequency.

With FUNCTION switch on BAND REJECT, the minimum reject band or null at any frequency is obtained by setting the high cut-off frequency (left-hand frequency dial and band multiplier switch) higher than the desired frequency by a factor of approximately 2, and setting the low cut-off frequency (right-hand frequency dial and multiplier switch) lower than the desired frequency by a factor of approximately 0.5.

2.4 TERMINALS

INPUT - Two combination-type binding post terminals are provided on the front panel. The red terminal is used for the input signal and the black terminal for input signal ground. A parallel BNC coaxial connector is located on the rear of the chassis.

OUTPUT - Two combination-type binding post terminals are provided on the front panel. The red terminal is used for the output signal and the black terminal for output signal ground. A parallel BNC coaxial connector is located on the rear of the chassis.

2.5 LINE VOLTAGE AND FUSES

The Filter, as normally shipped, is connected for operation from an a-c power source of 105 to 125 volts, 50 to 400 cycles, and uses a one ampere slow-blow line fuse that is mounted on the rear of the chassis. It may be modified to operate from a 210 to 250 volt line by removing the two jumpers from the four terminal barrier strip, located directly underneath the power transformer, and adding a jumper between terminals 2 and 3 of the barrier strip. A 1/2 ampere slow-blow fuse should be used for 210-250 volt operation.

SECTION 3
CIRCUIT DESCRIPTION

3.1 INTRODUCTION

The Schematic Diagram, Figure 14, of the Filter is attached to the rear cover. The darker lines on the Filter schematic show the main signal paths. As shown in the Simplified Schematic Diagram, Figure 2, the Filter consists basically of an input amplifier, a high-pass filter section, and a low-pass filter section.

3.2 DETAILED DESCRIPTION

INPUT AMPLIFIER

The input amplifier is a three-stage feedback amplifier that acts as a low impedance driving source to the RC circuits following it and supplies extra gain to compensate for the cathode follower losses. The first two stages (V1A and V1B) are RC coupled, and the remaining stages are direct coupled. The feedback signal is derived from the cathode of V2A, and is fed back to the cathode of V1A where it is compared to the input signal at the grid of V1A.

HIGH-PASS SECTION

This section includes four cascaded RC filter sections coupled by cathode-follower isolating stages. Each RC filter section has a critical or cut-off frequency (identical for each section) determined by the particular values of R and C, which attenuates all frequencies below the cut-off frequency at 6 db/octave and passes all frequencies above it. The cut-off frequency of all four sections is adjusted simultaneously by the ganged switches (S200A,

B, C, and D) and the ganged potentiometers (R203, R213, R223, and R233). The four cascaded RC stages produce the 24 db/octave attenuation characteristic. All cathode-followers are conventional except V3 which is a two-stage "push-pull" cathode follower.

Depending on the frequency range desired, any one of four capacitors can be selected by the band multiplier switch. The frequency dial adjusts the value of resistance in the RC circuit to obtain a particular frequency within the selected range.

LOW-PASS SECTION

The low-pass section also consists of four cascaded RC filter sections coupled by isolating cathode-follower circuits. The cut-off frequency (identical for each section) is determined by the selected values of R and C. All four sections are adjusted simultaneously by the use of ganged switches (S300A, B, C, and D), and ganged potentiometers (R303, R313, R323, and R333). All frequencies below the cut-off frequency are passed while frequencies above the cut-off frequency are attenuated at 6 db/octave per section. The cascaded combination of the four RC sections results in a total attenuation of 24 db/octave.

SIGNAL PATH

The signal path in each of the three operating modes is determined by the position of FUNCTION switch, S100. This switch is a rotary switch with two wafers, S100A and S100B. The switching action, as shown in Figure 2, has been simplified for convenience in following the signal paths.

BAND-PASS MODE

When the Filter is operated in the band-pass mode (BP), the high-pass section and the low-pass section are connected in series. With FUNCTION switch, S100, on BAND PASS, the input signal is fed through the input amplifer and coupled from the output of V5A to the high-pass section. From the output of the high-pass section, the signal is fed through switch S100A to the input of the low-pass section. The signal is then passed through the low-pass section and is coupled to the output terminals by switch S100B.

BAND-REJECT MODE

When the Filter is operated in the band-reject mode (BR), the high-pass section and the low-pass section are connected in parallel. With FUNCTION switch, S100 on BAND-REJECT, the input signal passes through the input amplifier, and at the output of V5A follows two parallel paths. One path is directly through the high-pass section. The other path is to the input of the low-pass section. The two signals are joined at the output of V9B, which is a signal summing point. At this point the two signals are added and coupled through the output filter network to the output terminals.

HIGH-PASS MODE

When the Filter is operated in the high-pass mode (HP), only the high-pass section is used. With FUNCTION switch S100 on HIGH PASS, the input signal is coupled through the input amplifier to the high-pass section. From the output of the high-pass section, the signal is coupled by switch S100B through V9B to the output terminals.

POWER SUPPLY

The power supply employs a full-wave rectifier, a filter network, and a series voltage regulator. Voltage regulation is accomplished by tubes V7 and V2B. Any change in the B+ is sensed by the grid of V2B resulting in a change in current flow through this tube. This change in current changes the voltage at the control grid of V7 which causes a change in current flow through this tube in such a manner as to counteract the original change in B+. Thus, the series regulator compensates for line voltage fluctuations, further reducing the output noise of the filter.

3.3 PRINCIPLES OF OPERATION

LOW-PASS FILTER SECTION

As shown in the Simplified Schematic Diagram, Figure 2, the Filter consists of an input amplifier, a high-pass filter section and a low-pass filter section. The low-pass filter section consists of two similar low-pass circuits connected in series. The simplified schematic of one low-pass circuit is shown in Figure 5.

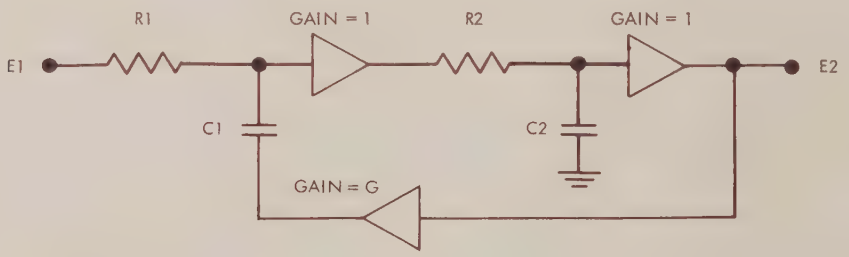


Figure 5. Simplified Low-Pass Circuit

A portion of the output signal G E_2 is fed back to the first capacitor C1. If both capacitors and resistors are equal, the circuit has a transfer function of:

$$\frac{E_2}{E_1} = \frac{1}{j^2\omega^2 R^2C^2 + j\omega RC\,(2-G) + 1}$$

At the cut-off frequency where $j^2\omega^2 R^2C^2 + 1 = 0$ or $\omega_{co} = 1/RC$ the gain of the circuit becomes $1/(2-G)$. The peaking of the response curve for three different values of the peaking factor A is shown in Figure 6, where $A = 1 - G/2$.

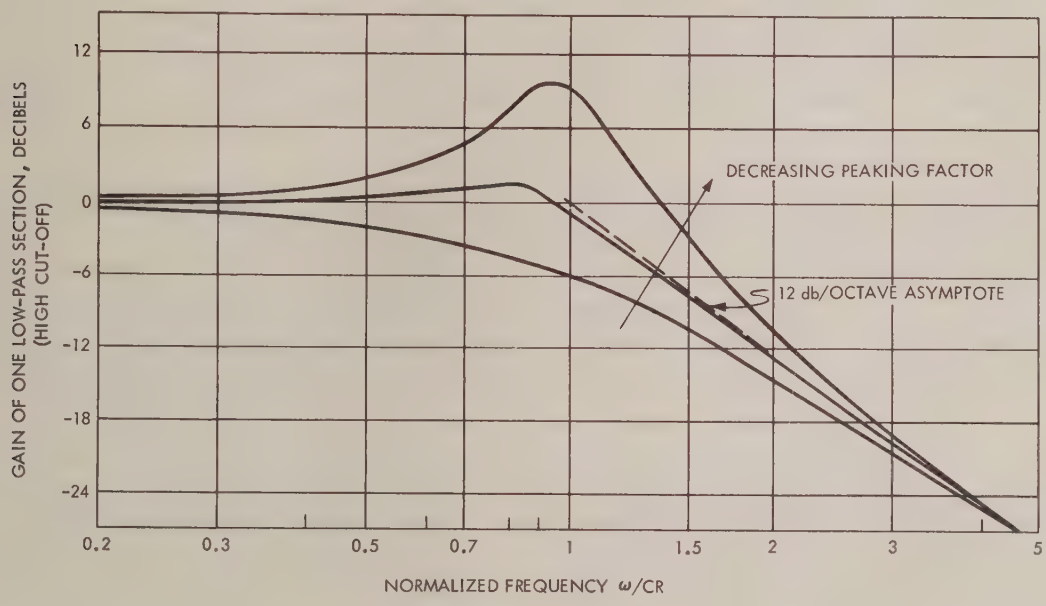


Figure 6. Effect of Corner Peaking

The middle curve is used in the Filter and is obtained by setting the peaking factor A to approximately 0.6 which corresponds to a gain G of approximately 0.8. This results in a gain of approximately -1.5 db at the cut-off frequency, and an attenuation slope of 12 db/octave for each low-pass circuit. The two similar circuits combine to achieve a gain of -3 db at the cut-off frequency and an attenuation slope of 24 db/octave.

HIGH-PASS FILTER SECTION

The high-pass filter section is composed of two similar high-pass circuits. The basic circuit is shown in Figure 7.

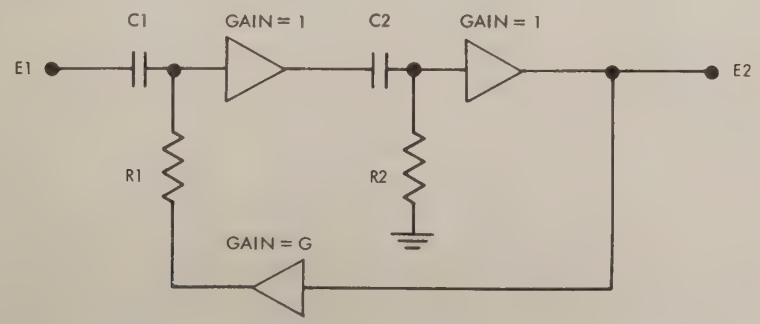


Figure 7. Simplified High-Pass Circuit

The feedback signal GE_2 is fed to the first amplifier through resistor R1. If both capacitors and resistors are equal the circuit has a transfer function of:

$$\frac{E_2}{E_1} = \frac{j^2\omega^2 R^2C^2}{j^2\omega^2 R^2C^2 + j\omega R C - (2-G) + 1}$$

At the cut-off frequency where $\omega_{co} = 1/C R$ the gain of the circuit becomes $1/(2-G)$.

The response curves of one high-pass circuit are symmetrical to the curves shown in Figure 6 about the axis of normalized frequency of unity. The middle curve is used in the Filter and is obtained by setting the peaking factor A to approximately 0.6 giving a gain of approximately -1.5 db at the cut-off frequency, and an attenuation slope of 12 db/octave for each high-pass circuit. The two similar circuits combine to achieve -3 db at the cut-off frequency and an attenuation slope of 24 db/octave.

EFFECTS OF PEAKING FACTOR

Choosing a peaking factor of approximately 0.6 obtained by selecting a gain of approximately 0.4 in the feedback amplifier results in relatively small (0.75 db) peaks in the attenuation curve, but reduces the corner frequency attenuation by 9 db from that obtained from four independent RC sections with unity peaking factor. For most applications, the Filter is superior because of the higher gain near the corner frequencies. Figure 8 shows a typical band-pass characteristic for a low cut-off frequency of 40 cps, and a high cut-off frequency of 160 cps. The response of the Filter is shown by the solid curve, and the response of a filter without a peaking feedback loop is shown by the dashed curve.

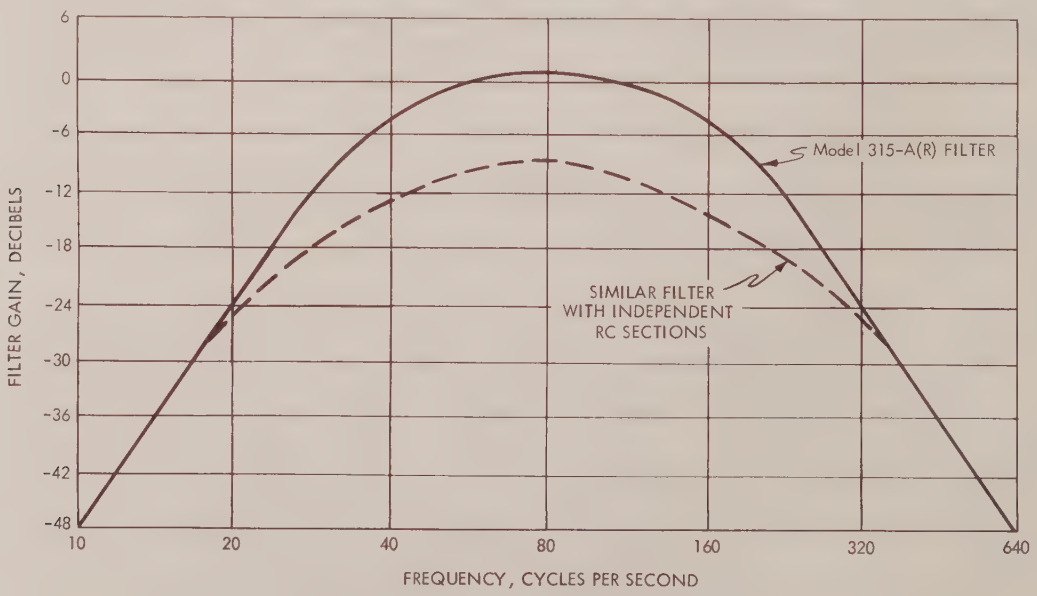


Figure 8. Effect of Corner Peaking on Pass-Band

TRANSFER FUNCTIONS

The transfer functions (output voltage over input voltage) for the three modes of operation can be expressed as follows:

$$\text{BAND-PASS:} \quad \frac{\omega^4 T_1^4}{(1 + 2j A\omega T_1 - \omega^2 T_1^2)^2 (1 + 2j A\omega T_2 - \omega^2 T_2^2)^2}$$

$$\text{BAND-REJECT:} \quad \frac{1}{(1 + 2j A\omega T_1 - \omega^2 T_1^2)^2} + \frac{\omega^4 T_2^4}{(1 + 2j A\omega T_2 - \omega^2 T_2^2)^2}$$

$$\text{HIGH-PASS:} \quad \frac{\omega^4 T_1^4}{(1 + 2j A\omega T_1 - \omega^2 T_1^2)^2}$$

where the low cut-off frequency is $1/2 \pi T_1$ and the high cut-off frequency is $1/2 \pi T_2$. The value of the peaking factor A, which is normally unity for filters composed of independent resistance-capacitance elements, is fixed at approximately 0.6. This value produces gain-peaks of approximately 0.75 db and reduced attenuation at the cut-off frequencies compared to the attenuation of a filter with unity peaking factor.

3.4 GENERALIZED FILTER CHARACTERISTICS

The gain and phase characteristics of the Filter for any one of the three operating modes can be plotted from the curves shown in Figures 9 and 10.

BAND-PASS MODE

The gain at any frequency is the sum of the gains (in decibels) of the high and low cut-off attenuation curves. For example as shown in Figure 9, if the cut-off frequencies are separated by a factor of four, the high cut-off frequency is at $f/f_H = 1$, the mid-band frequency (geometric mean of high and low cut-off frequencies as shown in Figure 3) is at $f/f_H = 0.5$, and the mid-band gain is 0.75 db. The low cut-off frequency is at $f_L/f = 1$, the mid-band frequency is at $f_L/f = 0.5$, and the mid-band gain is 0.75 db. The total mid-frequency gain is then 1.5 db. The gain at the high cut-off frequency is -3 db due to the low-pass section ($f/f_H = 1$), and 0.3 db due to the high-pass section ($f_L/f = 0.25$), resulting in a total gain of -2.7 db. Also, the gain at the low cut-off frequency is -2.7 db because the two attenuation curves are symmetrical about the mid-band frequency. As many other points as required can be similarly obtained from Figure 9.

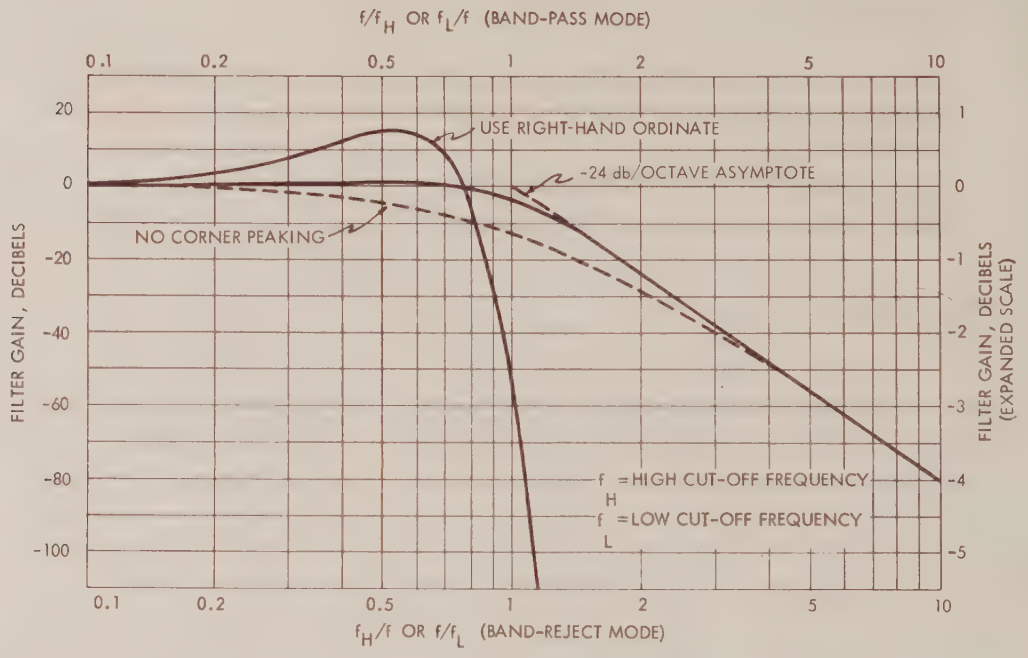


Figure 9. Normalized Attenuation Characteristics

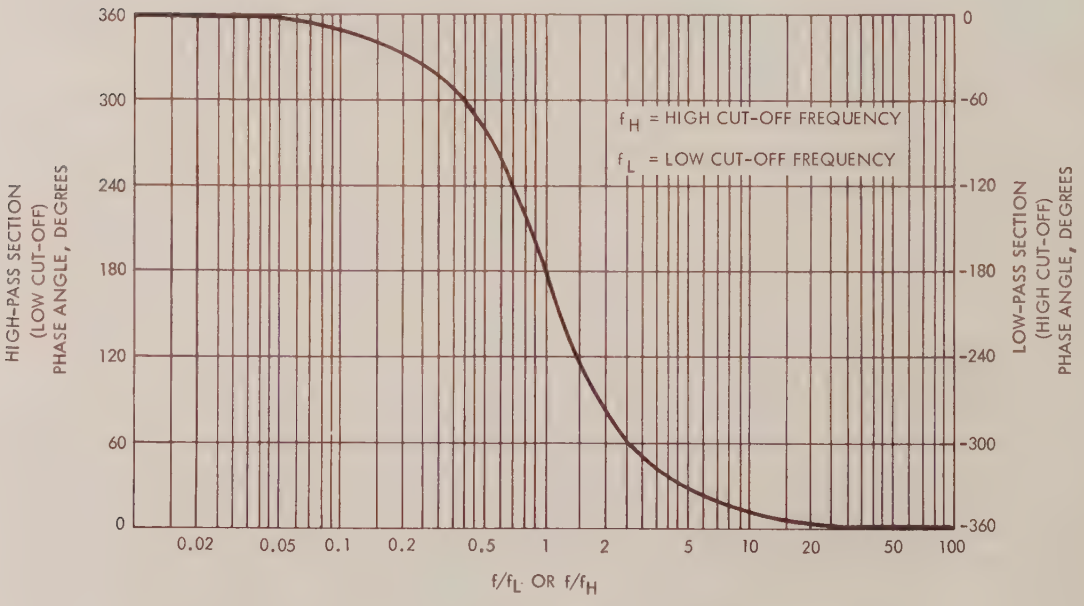


Figure 10. Normalized Phase Characteristics

The phase angle at any frequency is the sum of the angles due to the high and low cut-off attenuation curves. For example, as shown in Figure 10, if the cut-off frequencies are separated by a factor of four, the phase angle due to the low-pass section is approximately -180° at the high cut-off frequency ($f/f_H = 1$), -80° at mid-band ($f/f_H = 0.5$) and -30° at the low cut-off frequency ($f/f_H = 0.25$). The phase angle due to the high-pass

section is approximately +30° at the high cut-off frequency ($f/f_L = 4$), +80° at mid-band ($f/f_L = 2$), and +180° at the low cut-off frequency ($f/f_L = 1$). Therefore, the total phase angle is -150° at the high cut-off frequency, zero at mid-band, and +150° at the low cut-off frequency. Phase angles at other frequencies can be similarly obtained from Figure 10.

BAND-REJECT MODE

When the Filter is used in the band-reject mode, the gain and phase of the individual sections is determined in the same manner as that used for the band-pass mode. These gains and phase angles due to the high- and low-pass sections cannot be added directly to obtain total gain and phase angle. First, it is necessary to expand the vector (magnitude and phase) obtained from the characteristic curves of the low-pass section into its real and imaginary components. These components must then be added arithmatically to those obtained from the curves of the high-pass section. The resulting components are then converted into a magnitude and phase angle.

HIGH-PASS MODE

When the Filter is used in the high-pass mode, the gain can be plotted from Figure 9 by considering either one of the abscissas labeled "f_H/f" or "f_L/f". The desired cut-off frequency is at unity, and the curve is symmetrical to the one shown about the unity point on the abscissa. Phase angle is obtained from Figure 10 by using either scale on the abscissa and the left-hand ordinates.

An example of Filter characteristics in band-pass mode for a frequency separation factor of 10 is shown in Figure 11. The low cut-off frequency is at 10kc, the mid-band frequency at 31.6kc (geometric mean of high and low cut-off frequencies) and the high cut-off frequency is at 100kc.

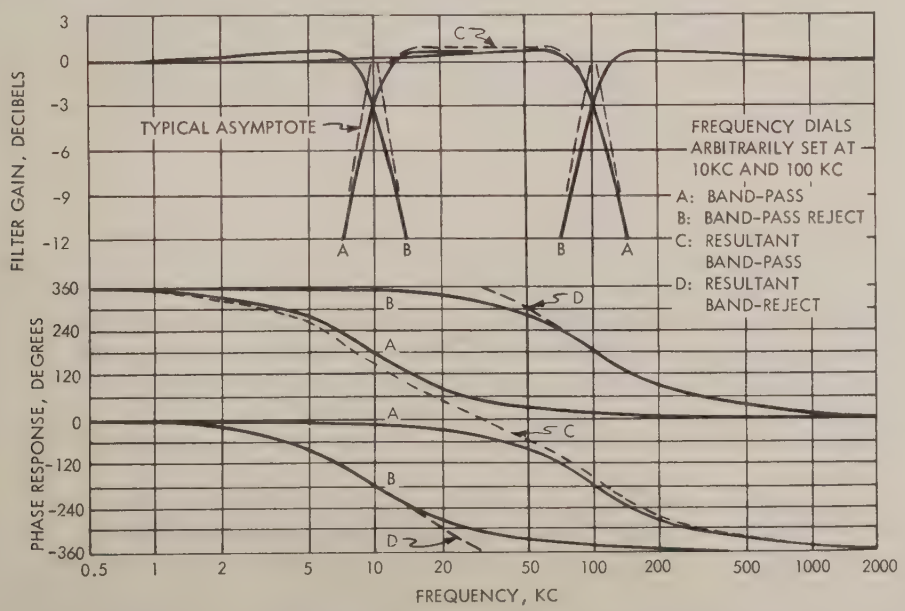


Figure 11. Amplitude and Phase Characteristics

SECTION 4
MAINTENANCE

4.1 INTRODUCTION

All components in the Filter are of the highest quality and should have a long trouble-free life because they are operated well below their design ratings. The following procedure facilitates locating the source of trouble if the Filter does not function properly.

NOTE

To take the chassis out of the cabinet, remove the two lower inner-most screws from the rear plate, and slide the chassis out from the front of the cabinet. In the rack model it is necessary to remove an additional four front panel nickel plated phillips screws.

4.2 TUBE COMPLEMENT CHECK

Before performing any maintenance, turn on the Filter, and make certain that the correct tubes are inserted properly in their respective sockets as shown in the top view in Figure 14. Apply power to the Filter, and note whether the filaments of the tubes are lit. If any of the filaments of any tube fails to light after sufficient warm up time, replace the tube.

The likeliest source of instrument failure is the vacuum tubes since they have an inherently shorter life. Therefore, if the Filter fails to operate after the initial tube check described above, install new tubes as required. The type number of each tube is clearly marked on the chassis adjacent to the tube.

4.3 FUSE FAILURE

A cartridge fuse (1 amp at 115 vac, 1/2 amp at 230 vac), located in the back of the chassis, is used in the primary circuit of the power transformer to protect the power supply components from short circuit. The rating of this fuse is selected for proper protection of the instrument and the fuse should be replaced with one of the same type and rating.

If a fuse failure is detected, the following procedure is recommended before replacing the fuse:

a. Remove the rectifier tube V6, and disconnect the power cord. Measure the dc primary resistance of the power transformer which should be approximately 5 ohms with primary jumpered for 115 vac, and approximately 20 ohms with primary jumpered for 230 vac. A lower resistance indicates a shorted primary.

b. Insert a new fuse, connect the power, and then, with V6 still out, check the primary and the secondary voltages of the transformer. If the voltages are correct, the transformer is functioning properly.

c. Prior to inserting a new rectifier tube, disconnect the power and check the dual filter capacitor, C503. A shorted capacitor can be detected by connecting an ohmmeter (low range) directly across it. If these capacitors are not shorted, check the unregulated +335-volt supply and regulated +265-volt supply to determine if they are shorted to each other or individually to ground. The unregulated +335 volts can be checked conveniently at the plate of V7. The regulated +265 volts can be check at the plate of V4, V5.

d. If the above procedure has not uncovered any faulty components or wiring, the rectifier tube may be the cause of the trouble and should be replaced.

4.4 POWER SUPPLY

If the equipment is not functioning when the rated line voltage is applied and the instrument is powered as indicated by the pilot light or visible tube filaments, it is advisable to check the power supply.

The positive (+) unregulated supply voltage, as derived from the cathode of the rectifier tube V6, is filtered in a capacitor-input, single-section, pi-filter consisting of C503 and L501. The unregulated supply voltage at rated line voltage should be approximately +335 volts.

If the unregulated voltage deviates from its proper value, replace the rectifier V6. If after replacing V6 there is no change in the voltage level, check the total current drain by measuring the voltage across L501 which, under normal conditions, should be approximately 25 volts. If the voltage is appreciably higher than normal, the equipment is drawing excessive current. The excess current may be due to a low-resistance path in the dual filter capacitor C503 or to incorrect d-c output level of the input amplifier or cathode followers.

Since both stages (V7 and V2B) of the a-c regulator are RC coupled, their d-c levels are independent so that the voltage levels of each stage can be checked independently according to the Voltage / Resistance Chart, Figure 14. Too large a voltage drop across V7 suggests excessive grid bias which could be caused by a leaky C504. The plate voltage of V2B may vary considerably from the indicated value as shown in the Voltage and Resistance chart since this tube derives its bias from grid current which varies from tube to tube.

4.5 INPUT AMPLIFIER V1, V2A, AND V5A (BAND-PASS MODE)

Due to RC coupling from the plate of V1A to the grid of V1B, there is no d-c feedback and the d-c levels are determined as follows:

V1B grid is at 0 volts.

R111 and R112 set the voltages of V1B plate and cathode.

Voltage at V1B plate appears on V2A grid.
(no current flows through parasitic suppressor R113).

Voltage at V2A cathode should be only a few volts more positive than V2A grid due to cathode follower action.

Voltage at V1A cathode is set by voltage at V2A cathode and voltage divider resistors, R104 and R114, in cathode of V2A.

Voltage on cathode of V2 is divided down by R117 and R126 and is used to set grid of V5A. Cathode-follower action sets V5 cathode a few volts higher.

Voltage at V1A plate is determined by voltage at V1A cathode and resistors R106 and R107.

A malfunction in the input amplifier can be most easily found if the voltages are checked in the order described.

4.6 REMAINING STAGES (BAND-PASS MODE)

All of the remaining stages are types of cathode followers. Stage V3 can be considered as a cathode follower by considering the bottom tube to be a simple d-c resistance.

In all cases, due to cathode-follower action, the cathode of each stage will be a few volts higher than the grid of the same stage if the circuit is working properly. The cathode-followers are coupled in the following order:

R214 and R215 set voltage at V4A grid.

Cathode-follower action sets V4A cathode a few volts higher.

Voltage at V4A cathode is divided down by R217 and R218 and is used to set the level of V3 grid. Due to cathode-follower action, this also sets level of V3A cathode and V3B plate a few volts higher. V3B grid is at zero volts and its cathode should be a few volts higher.

R234 and R235 set voltage at V4B grid.

Cathode-follower action sets V4B cathode, a few volts higher.

Voltage V4B cathode is divided down by R237 and R239 and is used to set level of V5B grid. As above, level of V5B is set a few volts higher.

R305 and R307 set voltage at V8A grid.

Voltage at junction of R308 and R309, which is approximately at the same voltage as the V8A cathode is fed to V8B grid. This sets voltage of V8B cathode a few volts higher.

Voltage at V8B cathode sets voltage at V9A grid, at same value. This sets voltage at V9A cathode a few volts higher.

With FUNCTION switch S100 on BAND REJECT or BAND PASS, voltage at V9A cathode sets voltage at V9B grid at same value. This sets voltage at V9B cathode, a few volts higher.

With FUNCTION switch S100 on BAND REJECT, voltage at cathode on V4B is fed to positive side of C405A through adding resistor R403.

With FUNCTION switch S100 on HIGH PASS, voltage at V4B cathode is divided by R240 and R241 and sets voltage at V9B grid. This sets voltage at V9B cathode, a few volts higher.

Any break in these chains of slowly rising voltage from grid to cathode to grid to cathode indicates that the stage, or its associated circuitry, is malfunctioning and should be carefully checked.

4.7 SIGNAL TRACING ANALYSIS

With FUNCTION switch on BAND PASS, apply a 2,000-cps, 5-volt, rms sine wave to the INPUT of the filter. Set the HIGH PASS frequency to 20 cps and the LOW PASS frequency to 200kc. When the instrument is operating properly this 2,000-cps test signal will pass through the Filter unchanged and appear at the OUTPUT with equal amplitude. If the test signal does not appear at the OUTPUT of the Filter it is advisable to first localize the malfunction by determining where the test signal fails to appear within the instrument.

Test points in the Filter with their correct signal voltages are listed in Table 1, for a 5-volt rms sine wave input. If the test point voltage differs appreciably from the correct voltage, all of the components, wiring, and voltage and resistance readings to ground associated with the tube(s) preceding the test point should be checked.

TABLE 1

TEST POINT VOLTAGES

Test Point		Correct Signal Voltage
Tube No.	Pin No.	
V1A	PLATE	0.6
V1B	PLATE	17.5
V2A	CATHODE	17.0
V3A	CATHODE	8.2
V4A	CATHODE	8.0
V5B	CATHODE	7.8
V4B	CATHODE	7.6
V8A	CATHODE	7.4
V8B	CATHODE	6.8
V9A	CATHODE	6.5
V9B	CATHODE	6.0

HIGH PASS Frequency: 20 cps
LOW PASS Frequency: 200kc
INPUT: 5V rms at 2000 cps
FUNCTION switch on BAND PASS

4.8 TUNING CIRCUITS

The tuning capacitors are switched four at a time by the multiplier switches (S200 and S300) as shown in Figure 14. The tuning resistances are varied by the tuning dial that turns four potentiometers through a system of gears. The trim resistors and angular orientation of these potentiometers are carefully adjusted at the factory for proper tracking and tuning. No attempt should be made to replace the potentiometers, since such replacement would require calibrating a new dial. The trim resistors can be replaced after repair according to instructions in the detailed test procedures given in Table 2 of Section 5.

SECTION 5

CALIBRATION AND ADJUSTMENT

5.1 INTRODUCTION

If it is desired to test the Filter for its conformance to operating specifications or if the Filter is scheduled for periodic calibration the following should be observed:

CUT-OFF FREQUENCY CALIBRATION

The high and low cut-off frequencies, as defined below, should be within ±10% of the corresponding dial reading. KROHN-HITE Electronic Filters are calibrated to conform to the following:

From passive Filter terminology, the cut-off frequency is the frequency at which the gain of the Filter is 3 db down from the gain at the middle of the pass-band (band-pass mode), or 3 db down from the zero db reference (band-reject and high-pass modes). When checking the cut-off frequency calibration accuracy as defined above refer to Figure 12. Cut-off frequency gain is the amount by which the Filter output at the cut-off frequency differs from the mid-band or mean frequency output. This gain varies with separation of the cut-off frequencies and is plotted in Figure 12 as a function of the ratio of high to low cut-off frequencies. Cut-off frequency gain approaches minus 3 db for wide separations (curve A of Figure 3), has a maximum of about minus 4.2 db for a separation factor of four (curve C of Figure 3), and goes to zero db when the cut-off frequencies coincide (curve D of Figure 3).

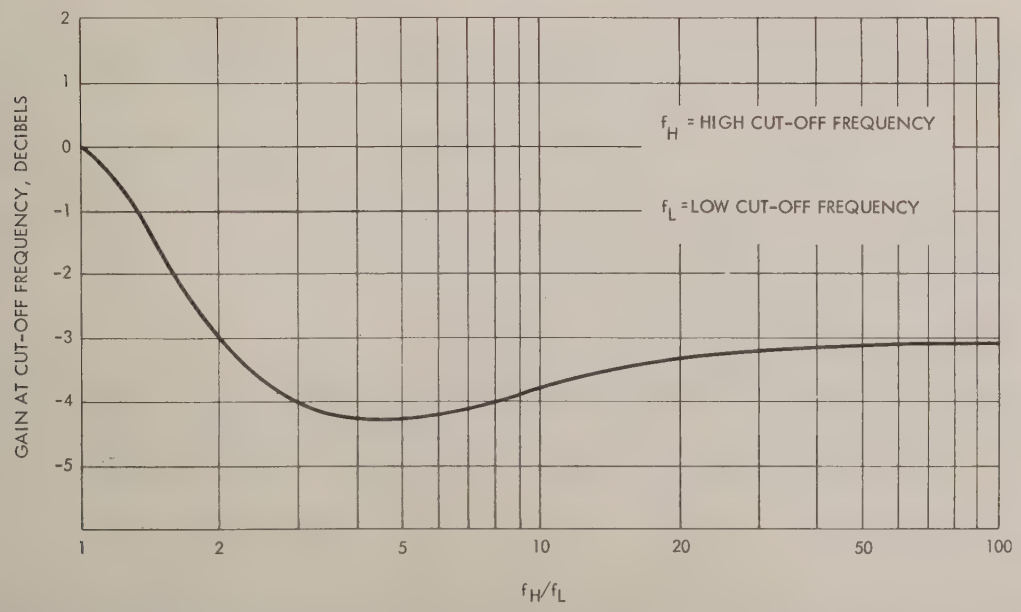


Figure 12. Cut-Off Frequency Gain (Band-Pass Mode)

INSERTION LOSS

In the band-pass mode, the Filter output voltage under open circuit conditions will be within ±1 db of the input voltage for all frequencies within the pass-band. The pass-band, for the purpose of specifying insertion loss, is defined as the frequency spectrum from ten times the low cut-off frequency setting to one tenth of the high cut-off frequency setting. To determine the insertion loss (pass-band gain) accurately, the high and low cut-off frequencies must be separated by a factor of at least one hundred, and the measuring frequency must be the geometric mean of these frequencies.

In the band-reject mode, the Filter output voltage under open-circuit conditions will be within ±1 db of the input voltage for all frequencies above or below the rejection band. For the purpose of specifying insertion loss, the gain is measured at ten times the high cut-off frequency setting and one-tenth of the low cut-off frequency setting.

In the high-pass mode, the Filter output voltage under open-circuit conditions will be within ±1 db of the input voltage for all frequencies up to the upper 3 db point. The gain is measured at ten times the cut-off frequency for the purpose of specifying insertion loss.

ATTENUATION SLOPE

A typical attenuation curve is shown in Figure 9. At the cut-off frequency, the slope is approximately 12 db per octave, and at the 12 db point the slope has essentially reached its nominal value of 24 db per octave. The slope of the straight portion of the curve may be slightly less than 24 db per octave at certain frequencies because of cross-coupling effects.

OUTPUT IMPEDANCE

The rated output impedance is the source impedance and also the minimum load that may be connected to the Filter. For the minimum value of load, the insertion loss will be approximately 6 db. Lower values of load resistance will not damage the instrument but will increase the distortion. Higher values of external load may be used with no sacrifice in performance and correspondingly lower insertion loss. In KROHN-HITE Electronic Filters, there is no requirement for the load impedance to match the output impedance.

INTERNALLY GENERATED HUM AND NOISE

The internally generated hum and noise measurement is based on the use of a Ballantine Model 310 Voltmeter, or equivalent. The measurement is made with the INPUT terminals connected by a low impedance shorting jumper, no other external signal connections to the instrument, and the voltmeter leads shielded.

MINIMUM NULL

As described in Section 1, a sharp null in the band-reject mode is obtained by setting the high and low cut-off frequencies at a factor of approximately

2 from the desired null frequency. A sharper null may be obtained by successive readjustment of the two frequency dials, while monitoring the instrument output.

DISTORTION

Filter distortion is a function of several variables and is difficult to specify exactly. In general, if the Filter is operated within its ratings, distortion products introduced by the Filter and not present in the INPUT signal will not exceed 0.5% of the OUTPUT signal. In most cases distortion will be considerably less than 0.5%.

TRANSIENT RESPONSE

The term transient response is sometimes used in reference to filters in an attempt to specify performance when impulse voltages are applied to the input. Mathematical analysis and laboratory measurements show that for a given input signal (complex wave, square wave, step function, etc.) all Filters will produce an output signal that depends only on the transfer function vs. frequency and is not affected in any manner by the electrical composition of the Filter (RC, m-derived, etc.). The phase and/or amplitude of the individual input signal frequency components may, however, suffer undue distortion at the output if the Filter does not have a smooth transfer characteristic with no pronounced peaks. Distortion of this nature is minimized by the design of KROHN-HITE Filters. These Filters represent the optimum practical approach to ideal Filter characteristics combined with versatility to give unsurpassed performance.

5.2 DETAILED TEST PROCEDURE

GENERAL

1. All d-c voltage measurements should be made with a VTVM, and made with respect to ground (chassis), unless otherwise specified.

2. All measurements should be made with a line voltage having less than 1% distortion.

3. Give the instrument a thorough visual inspection, looking particularly for oil leaks, discoloration of the chassis, component panels, or components, and loose or broken wires, poor solder connections, etc.

4. Check that all tubes are seated firmly in the correct sockets and that all heaters light.

5. Check operation of POWER switch.

6. Check that wires do not touch the gears and that the dials rotate smoothly.

TEST EQUIPMENT REQUIRED

1. Audio Oscillator - capable of supplying at least 10 volts rms from 10 cps to 1 megacycle with frequency calibration better than ±2% and distortion less than 1%. (Frequency may be checked with a frequency counter.)

2. A-C Millivoltmeter - reading from 10 mv full scale to 10 volts (rms) full scale (db scale desirable).

3. Oscilloscope - having direct coupled horizontal and vertical amplifiers with equal phase characteristics to at least 2 kc and vertical sensitivity of 10 mv per division.

4. Vacuum Tube Voltmeter - reading to 500 volts dc.

5. A-C Voltmeter - to measure line voltage.

6. Resistance bridge - accuracy of at least 1%.

VOLTAGE MEASUREMENTS (BAND-PASS MODE)

1. Voltage measurement of B plus. Read d-c voltage at plate of V4 or V5.
   Tolerance: +250 to +300 volts

2. Voltage measurement of input amplifier operating point. Read d-c voltage on plate of V1A.
   Tolerance: +140 to +190 volts

3. Voltage measurement of input amplifier operating point. Read d-c voltage on plate of V1B.
   Tolerance: +90 to +140 volts

4. Voltage measurement of OUTPUT d-c level. Read d-c voltage across OUTPUT terminals.
   Tolerance: zero to plus 0.15 volt.

   If readings are incorrect, check output circuit and capacitor C405.

TEST PROCEDURES

Table 2 contains detailed test procedures to check Filter performance. The procedures are to be performed in the given order (1 through 58). Throughout the procedures, "low-pass" is abbreviated "LP" and "high-pass" is abbreviated "HP". Note that LOW-PASS dial and multiplier refers to the right-hand frequency dial and band multiplier switch, and that HIGH-PASS dial and multiplier refers to the left-hand frequency dial and band multiplier switch.

TABLE 2. DETAILED TEST PROCEDURE

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
1a.	Overall operation check	BP	19	X10	210	X100	2.5	2000
	Output signal should be from 2.25 to 2.75 volts.							
b.	Same	BP	19	X10	210	X100	2.5	20
	Output signal should be less than 5 millivolts.							
2a.	Gain adjustment input loop	HP	20	X1000	20	X1	--	100kc
	Increase input signal until output signal is 1.0 volt rms. Measure a-c voltage of cathode of V2A. Record this voltage for use in step 2b.							
b.	Same	HP	20	X1000	20	X1	1.0	1kc
	Measure a-c voltage at cathode of V2A. Adjust R104 for same voltage at step 2a, ±0.4 db.							
c.	Same	HP	20	X1000	20	X1	1.0	100kc
	Output signal should be 0.95 to 1.05 volts. If off, adjust C117.							
d.	Same	HP	20	X1	20	X1	1.0	1kc
	Output signal should be 0.95 to 1.05 volts. If off, adjust R117.							
e.	Same	HP	20	X1	20	X1	1.0	100kc
	Output signal should be 0.95 to 1.05 volts. If off, adjust C128.							
f.	Same	HP	20	X1	20	X1	1.0	100kc to 1mc
	Sweep oscillator to 1 megacycle. Output signal should be constant (± 0.5 db) up to 500kc and be less than 3 db down at 1 megacycle.							
g.	Same	HP	20	X1000	20	X1	1.0	100kc to 1mc
	Sweep oscillator to 1 megacycle. Output signal should be constant (± 0.5 db) up to 500kc and be less than 3 db down at 1 megacycle.							
3a.	Gain adjustment	BR	20	X1	20	X1	1.0	1kc
	Output signal should be 0.95 to 1.05 volts. If off, adjust R123.							
b.	Same	BR	20	X1	20	X1	1.0	100kc
	Output signal should be 0.95 to 1.05 volts. If off, adjust C129.							
4.	Output impedance	BP	19	X1	210	X100	2.5	200
	Connect a 500-ohm resistor across OUTPUT terminals. Output signal should be 1.00 to 1.50 volts.							
5.	Corner peaking, Low-pass frequency	BP	60	X1	60	X100	2.5	300
	Read output signal in db. Switch LP frequency multiplier to X10 position, and read new value of output signal in db. Tolerance is zero to +1.5 db change from first reading.							
6.	Corner peaking, High-pass frequency	BP	60	X1	60	X100	2.5	1200
	Read output signal in db. Switch HP frequency multiplier to X10 position, and read new value of output signal in db. Tolerance is zero to +1.5 db change from first reading.							
7.	Overload amplitude	BP	190	X1	210	X10	--	600
	Set oscillator amplitude just below point at which scope begins to show distortion. Output signal should be greater than 4 volts and not distorted.							

TABLE 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
8.	Check leakage of input coupling capacitor	BP	190	X1	210	X10	2.5	600
	Connect oscillator to INPUT terminals through a 1-μf capacitor which has a leakage resistance greater than 100 megohms. Connect top INPUT terminal to plate of V8A (plus 265 volts) through a 1-megohm resistor. Set oscillator amplitude just below point at which scope begins to show distortion. Output signal must be greater than 2.5 volts. Note: An external source of plus 270 volts may be used for this step. Allow ample time for the capacitors to charge.							
9.	Gain change vs. HP tuning	BP	190 -19	X1	210	X1000	2.5	2000
	Rotate HP dial slowly from 190 to 19, and observe any changes in output voltage. Tolerance is 0 ± 0.5 db.							
10.	Gain changes vs. HP band switching	BP	19	X1	210	X1000	2.5	100kc
	Switch HP frequency multiplier successively to all four positions, and observe any changes in output voltage. Tolerance is 0 ± 0.5 db.							
11.	Insertion loss outside the rejection region	HP	19	X1	210	X1000	2.5	500kc
	Switch HP frequency multiplier successively to all four positions, and observe any changes in output voltage. Tolerance is zero ± 0.5 db.							
12.	Filter gain at upper frequency limit	BP	19	X1	210	X1000	2.5	200kc
	Output signal should be greater than 0.5 volt.							
13.	Filter gain at lower frequency limit	BP	19	X1	210	X1	2.5	20
	Output signal should be greater than 0.5 volt.							
14.	Output hum and noise	BP	30	X1	120	X1	Short Circuit	--
	Short INPUT using a short lead, and shield bottom of chassis if necessary with shielded connecting cables. Check noise reading for both positions of the power cord plug. Noise signal should be less than 500 microvolts.							
15.	10 cps maximum attenuation below pass-band frequency	BP	200	X1000	200	X1000	2.5	10
	Output signal should be less than 0.0025 volt.							
16.	20 kc maximum attenuation below pass-band frequency	BP	200	X1000	200	X1000	2.5	20kc
	Output signal should be less than 0.0025 volt.							
17.	20 kc maximum attenuation above pass-band frequency	BP	200	X10	200	X10	2.5	20kc
	Output signal should be less than 0.0025 volt.							

TABLE 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
18.	Check test oscilloscope phase shift at 2000 cps. Set oscillator for 2.5 volts at 2000 cps							
	Connect scope horizontal input to oscillator output, and adjust scope for a sweep 20 divisions wide. Remove scope horizontal input. Connect scope vertical input to oscillator output, and adjust scope for a line 20 divisions high. Connect both horizontal and vertical inputs to oscillator and check for equal horizontal and vertical phase shift in scope amplifier by noting a completely closed ellipse (straight line) at about a 45-degree angle.							
	Note: For all calibration steps 19 through 32, connect a 1500 ohm resistor across the Filter OUTPUT terminals.							
19.	Check phase calibration of HP dial at 600 cps	BP	60	X10	210	X1000	2.5	600
	Connect scope vertical input to cathode of V4B and horizontal to cathode of V5A through 10μf (non-electrolytic) capacitors to remove dc present at this point. Adjust HP dial to close the ellipse at about a 135 degree angle. Tolerance is a dial setting of from 56.4 to 63.6. If out of tolerance, loosen set-screws and reset dial.							
20.	3 db attenuation calibration of HP dial at 600 cps	BP	60	X10	210	X1000	2.5	600
	Switch HP frequency multiplier to the X1 position. With scope vertical input on cathode of V4B adjust oscillator output for a scope vertical deflection of exactly 20 divisions. Return HP frequency multiplier to the X10 position. Adjust HP dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance is a dial setting of from 56.4 to 63.6. If out of tolerance refer to Section 5.3 and repeat step 19.							
	Note: The a-c VTVM may be used for this and subsequent measurements instead of the scope if desired.							
21.	Check phase calibration of HP dial at 250 cps	BP	25	X10	210	X1000	2.5	250
	Proceed as in step 19, assuming that scope calibration and phase shift have not changed. Tolerance is a dial setting of from 23.5 to 26.5 If out of tolerance proceed as described in step 22.							
22.	3 db attenuation calibration of HP dial at 250 cps.	BP	25	X10	210	X1000	2.5	250
	Proceed as in step 20, switching HP frequency multiplier to X1 position to set scope and returning to X10 position for final reading. Tolerance is a dial setting of from 23.5 to 26.5. If out of tolerance refer to Section 5.4 and repeat step 21.							
23.	Check phase calibration of HP dial at 1800 cps	BP	180	X10	210	X1000	2.5	1800
	Proceed as in step 19, assuming that scope calibration and phase shift have not changed. Tolerance is a dial setting of from 170 to 190. If out of tolerance proceed as described in step 24.							
24.	3 db attenuation calibration of HP dial at 1800 cps	BP	180	X10	210	X1000	2.5	1800
	Proceed as in step 20, switching HP frequency multiplier to X1 position to set scope and returning to X10 position for final reading. Tolerance is a dial setting of from 170 to 190. If out of tolerance refer to Section 5.4 and repeat step 23.							

TABLE 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
25.	3 db attenuation calibration of HP dial at 60 on the dial for all bands	BP	60	--	210	×1000	2.5	--
	Follow procedure in step 20 for last three positions of HP multiplier switch. On each of these bands, adjust scope with multiplier switch in next lower position; then, restore multiplier switch so that HP frequency is equal to oscillator frequency, and adjust HP dial for a vertical deflection of 14 divisions. For first position (X1) of HP multiplier switch, it will be necessary to adjust scope at an oscillator frequency of 600 cps with HP frequency multiplier on X1 and then reduce oscillator frequency to 60 cps. Oscillator output voltage should be checked with scope to make certain that amplitude does not change at 60 cps. Adjust HP dial for a vertical deflection of 14 divisions. Tolerance (all bands) is a dial setting of from 56.4 to 63.6. In addition to checking 60 on dial on all bands, 200 on dial with multiplier set on X1000 (200 kc) should be checked. This can be checked in the same manner as 60 kc is checked, except that oscillator frequency is set at 200 kc. If out of tolerance at 60 on band 1 (X1) adjust C204 or C214. If out of tolerance at 60 on band 3 (X100) adjust C202 or C212. If out of tolerance at 60 on band 4 (X1000) adjust C201 or C211.							
26.	Check phase calibration of LP dial at 600 cps	BP	25	×1	60	×10	2.5	600
	Connect scope horizontal input to oscillator output, and adjust scope for a sweep 20 divisions wide. Remove scope horizontal input, and connect vertical input to oscillator output. Adjust scope for a line 20 divisions high. Phase shift of scope has been checked in step 18. Connect horizontal input to cathode of V4B and vertical input to Filter OUTPUT. Adjust LP dial to close ellipse at about 135 degrees. Tolerance is a dial setting of from 56.4 to 63.6. If out of tolerance, loosen setscrews and reset dial. Connect horizontal input to cathode of V4B.							
27.	3 db attenuation calibration of LP dial at 600 cps	BP	25	×1	60	×10	2.5	600
	Switch LP frequency multiplier to X100 position, and adjust oscillator output for a scope vertical deflection of exactly 20 divisions. Return LP frequency multiplier to X10 position. Adjust LP dial for a scope vertical deflection of 14 divisions (minus 3 db). Tolerance is a dial setting of from 56.4 to 63.6. If out of tolerance refer to Section 5.3 and repeat step 26.							
28.	Check phase calibration of LP dial at 250 cps	BP	25	×1	25	×10	2.5	250
	Proceed as in step 26, assuming that scope calibration and phase shift have not changed. Tolerance is a dial setting of from 23.5 to 26.5. If out of tolerance proceed as described in step 29.							
29.	3 db attenuation calibration of LP dial at 250 cps	BP	25	×1	25	×10	2.5	250
	Proceed as in step 27, switching LP frequency multiplier to X100 position to set scope and returning to X10 position for final reading. Tolerance is a dial setting of from 23.5 to 26.5. If out of tolerance refer to Section 5.4 and repeat step 28.							
30.	Check phase calibration of LP dial at 1800 cps	BP	25	×1	180	×10	2.5	1800
	Proceed as in step 26, assuming that scope calibration and phase shift have not changed. Tolerance is a dial setting of from 170 to 190. If out of tolerance proceed as described in step 31.							
31.	3 db attenuation calibration of LP dial at 1800 cps	BP	25	×1	180	×10	2.5	1800
	Proceed as in step 27, switching LP frequency multiplier to X10 position to set the scope and returning to X1 position for final reading. Tolerance is a dial setting of from 170 to 190. If out of tolerance refer to Section 5.4 and repeat step 30.							

TABLE 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
32.	3 db attenuation calibration of LP dial at 60 on dial for all bands	BP	25	X1	60	--	2.5	--
	Follow procedure of step 27 for first three positions of LP multiplier switch. On each of these bands adjust scope with multiplier switch in next higher position; then, restore multiplier switch so that LP frequency is equal to oscillator frequency, and adjust LP dial for a vertical deflection of 14 divisions. For last position (X1000) of LP multiplier switch, it will be necessary to adjust scope at an oscillator frequency of 6000 cps with LP frequency multiplier on X1000 and then increase oscillator frequency to 60 kc. Oscillator output voltage should be checked with scope to make certain that amplitude does not change at 60 kc. Adjust LP dial for a vertical deflection of 14 divisions. Tolerance (all bands) is a dial setting of from 56.4 to 63.6. In addition to checking 60 on dial on all bands, 200 on dial, with multiplier on X1000 (200 kc) should be checked. This can be checked in the same manner as 60 kc is checked, except that oscillator frequency is set at 200 kc. If out of tolerance at 60 on band 1 (X1) adjust C304 or C314. If out of tolerance at 60 on band 3 (X100) adjust C302 or C312. If out of tolerance at 60 on band 4 (X1000) adjust C301 or C311. Note: Remove 1500 ohm resistor from Filter OUTPUT terminals for remaining tests.							
33.	Check gain at 22 kc for narrowest band setting	BP	22	X1000	22	X1000	2.5	22,000
	Output signal should be between 0.75 and 1.25 volts.							
34.	Check HP corner peaking at 22 kc in X1000 position	BP	22	X1000	66	X1000	2.5	22,000
	Output signal should be between 1.25 and 2.5 volts.							
35.	Check LP corner peaking at 22 kc in X1000 position	BP	70	X100	22	X1000	2.5	22,000
	Output signal should be between 1.25 and 2.5 volts.							
36.	Check HP Filter components in X1000 position	BP	66	X1000	22	X1000	2.5	22,000
	Output signal should be between 0.009 and 0.033 volt.							
37.	Check pass-band gain for following settings:	BP	70	X100	66	X1000	2.5	22,000
		BP	20	X100	200	X100	2.5	6,000
		BP	20	X10	200	X10	2.5	600
		BP	20	X1	200	X1	2.5	60
	For each of above settings, output signal should be between 2.2 and 3.2 volts.							
38.	Check LP Filter section components for following settings:	BP	60	X1	20	X1	2.5	60
		BP	60	X10	20	X10	2.5	600
		BP	60	X100	20	X100	2.5	6,000
		BP	60	X1000	20	X1000	2.5	60,000
	For each of above settings, output signal should be between 0.01 and 0.05 volt.							
39a.	Overall operation check - 200 cps gain	BR	19	X1000	19	X100	2.5	200
	Output voltage should be between 2.3 and 2.7 volts.							
b.	Same	BR	19	X1	19	X1	2.5	200
	Output voltage should be between 2.3 and 2.7 volts.							

TABLE 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
40.	Output impedance	BR	19	X1	19	X1	2.5	200
	Connect a 1.5k ohm resistor across the OUTPUT terminals. Output signal should be 1.1 to 1.6 volts. Remove the 1.5k ohm resistor.							
41.	Overload amplitude	BR	210	X1	19	X1	--	600
	Set oscillator amplitude just below point at which scope begins to show distortion. Output signal should be greater than 3 volts and not distorted.							
42.	Gain change vs. HP tuning	BR	190 -19	X1	19	X1	2.5	600
	Rotate HP dial slowly from 190 to 19, and observe any changes in output voltage. Tolerance is ± 1.0 db.							
43.	Gain change vs. HP band switching	BR	19	X1	19	X1	1.0	100kc
	Switch HP FREQUENCY multiplier successively to all four positions, and observe any changes in output voltage. Tolerance is ± 1 db.							
44.	Filter gain at upper frequency limit	BR	19	X1	19	X1	1.0	500kc
	Output signal should be from 0.5 to 1.2 volts.							
45.	Filter gain at lower frequency limit (connect 1.5k load)	BR	19	X1	19	X1	2.5	1 cps
	Output signal should be greater than 1.25 volts.							
46.	Maximum attenuation (remove 1.5k load)	BR	210	X100	19	X1	2.5	600
	Output signal should be less than 0.0025 volt.							
47.	Null	BR	120	X10	30	X10	2.5	600
	Adjust both dials to minimize the signal. Output signal should be less than 0.02 volt.							
48.	1200 cps gain at null setting	BR	Null Setting	X10	Null Setting	X10	2.5	1200
	Output signal should be between 1 and 2.5 volts.							
49.	300 cps gain at null setting	BR	Null Setting	X10	Null Setting	X10	2.5	300
	Output signal should be between 1 and 2.5 volts.							
50.	100 kc gain	BR	60	X10	60	X1	2.5	100kc
	Output voltage should be between 2.25 and 2.75 volts.							
51.	Insertion loss outside rejection region	BR	19	X1	210	X100	2.5	500kc
	Switch HP FREQUENCY multiplier successively to all four positions, and observe any changes in output voltage. Tolerance is 0 ± 1 db.							
52.	3 db attenuation calibration of LP dial at 60 on the dial for all bands	BR	60	--	210	X1000	2.5	--
	Follow procedure of step 19 for first three positions of LP multiplier switch. On each of these bands, adjust scope with multiplier switch in the next higher position, restore multiplier switch so that LP frequency is equal to oscillator frequency, and adjust LP dial for vertical deflection of 14 divisions. For the last position (X100) of LP multiplier switch, adjust scope at an oscillator frequency of 6000 cps with LP frequency multiplier on X1 and then increase oscillator frequency to 60 kc.							

TABLE 2. DETAILED TEST PROCEDURE (Cont)

STEP	PROCEDURE	Mode	FREQUENCY SETTING				INPUT SIGNAL	
			HP Dial	HP Multiplier	LP Dial	LP Multiplier	Voltage	Frequency
STEP 52 (Cont)	Oscillator output voltage should be checked with scope to make certain that amplitude does not change at 60 kc. Adjust LP dial for vertical deflection of 14 divisions. In addition to checking 60 on dial for all bands, 200 on dial with multiplier set on X1000 (200 kc) should be checked. This can be checked in the same manner as 60 kc is checked, except that oscillator frequency is set at 200 kc. Note: On X1000 position, connect approximately 20 μf from cathode of V4B to ground. Tolerance (all bands) is a dial setting of from 54 to 66.							
53.	3 db attenuation calibration of HP dial at 60 on dial for all bands	BR	25	X1	60	--	2.5	--
	Follow procedure of step 26 for last three positions of HP multiplier switch. On each of these bands adjust scope with multiplier switch in the next lower position, restore multiplier switch so that HP frequency is equal to oscillator frequency, and adjust HP dial for vertical deflection of 14 divisions. For the first position (X1) of HP multiplier switch, adjust scope at an oscillator frequency of 600 cps with HP frequency multiplier on X10 and then decrease oscillator frequency to 60 cps. Oscillator output voltage should be checked with scope to make certain that the amplitude does not change at 60 cps. Adjust HP dial for vertical deflection of 14 divisions. In addition to checking 60 on dial for all bands, 200 on dial with multiplier set on X1000 (200 kc) should be checked. This can be checked in the same manner as 60 kc is checked, except that oscillator frequency is set at 200 kc. Tolerance (all bands) is a dial setting of from 54 to 66.							
54.	Gain at 60 cps	BR	60	X10	60	X10	2.5	60
	Output voltage should be between 2.25 and 2.75 volts.							
55.	Gain at 6 kc	BR	60	X10	60	X10	2.5	6000
	Output voltage should be between 2.25 and 2.75 volts.							
56.	Gain at 17 kc (corner peaking)	BR	60	X100	60	X10	2.5	17kc
	Output voltage should be between 2.25 and 3.2 volts.							
57.	Check pass-band gain for following settings:	BR	200	X1000	20	X1000	2.5	6000
		BR	200	X100	20	X100	2.5	600
		BR	200	X10	20	X10	2.5	60
		BR	200	X1	20	X1	2.5	6
	For each of above settings, output signal should be between 2.25 and 3.0 volts, except at 60 cps when signal is between 1.25 and 3.0 volts.							
58.	Check low-pass filter section components for following settings:	BR	200	X1	20	X1	2.5	60
		BR	200	X10	20	X10	2.5	600
		BR	200	X100	20	X100	2.5	6000
		BR	70	X1000	70	X100	2.5	22,000
	For each of above settings, output signal should be between 0.025 and 0.07 volt.							

5.3 ALIGNMENT OF DIAL TUNING POTENTIOMETER ASSEMBLIES

Figure 13A shows the rear view of the LP (low-pass) dial tuning potentiometer assembly, and Figure 13B shows the rear view of the HP (high-pass) dial tuning potentiometer assembly.

a. Set HIGH-PASS frequency dial (left-hand dial) to 60.

b. Connect a bridge between points A1-A2 (see Figure 13B) on the terminal board. The bridge should read 26.5K ohms ± 1% (resistance of potentiometer R203).

c. Repeat step b for points B1-B2, C1-C2, and D1-D2 (see Figure 13B). The resistance measurements should be within ±1% of those readings in Table 3.

d. If the resistance limits of steps b and c cannot be obtained, adjust the HIGH-PASS frequency dial to see if all measurements fall within the limits of Table 3 at one setting. If they do, loosen the dial, slip dial to 60, and tighten. If all the resistances do not fall within limits at one setting, loosen the gear on the potentiometer that is off, and readjust until it falls within limits.

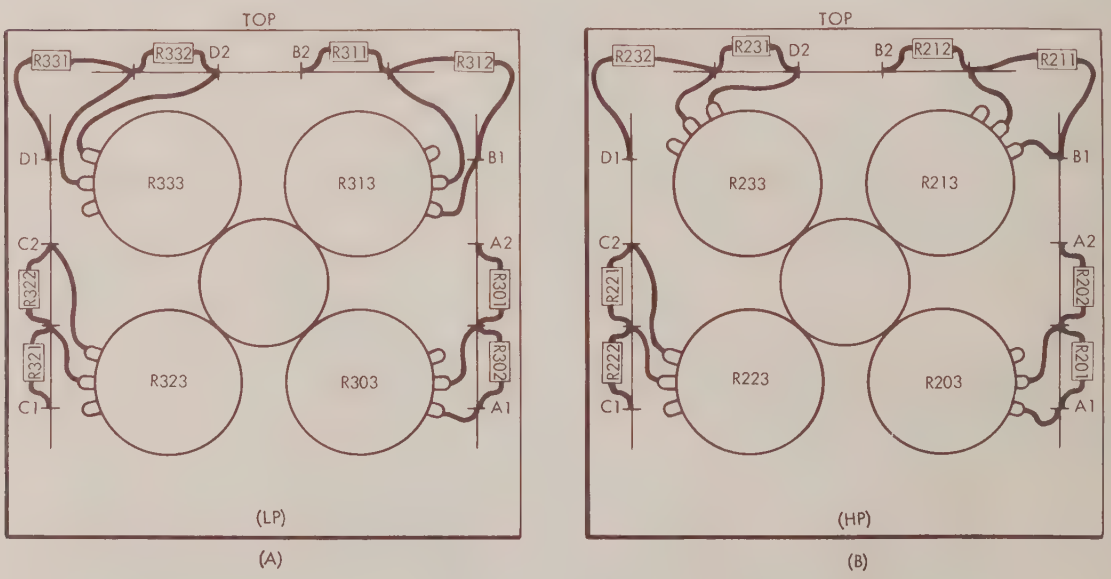


Figure 13. Rear View of Dial Tuning Potentiometer Assemblies

e. Set LOW-PASS frequency dial (right-hand dial) to 60.

f. Repeat steps b through c, but refer to Figure 13A. Slip dial or adjust individual potentiometer as described in step d as necessary to meet the limits of Table 3.

TABLE 3

LP AND HP POTENTIOMETER
RESISTANCE MEASUREMENTS

LP Pot. Resistances*		HP Pot. Resistances*	
Connect bridge across	Should read (ohms ±1%)	Connect bridge across	Should read (ohms ±1%)
A1-A2	26.0K	A1-A2	26.5K
B1-B2	27.7K	B1-B2	24.8K
C1-C2	26.0K	C1-C2	26.5K
D1-D2	27.7K	D1-D2	24.8K

*All resistance values given include the fixed trimming resistor associated with each potentiometer. All resistance values should be measured on a bridge capable of reading to at least 1% accuracy.

5.4 ADJUSTMENT OF TRIM RESISTANCE OF TUNING POTENTIOMETERS

When the high and low ends of the LOW-PASS and HIGH-PASS dials do not calibrate with respect to the center-of-dial (60) position during the detailed test procedures described in Table 2, refer to Table 4 for adjustment of trim resistances for the appropriate tuning potentiometers.

TABLE 4

TRIM RESISTOR ADJUSTMENT FOR TUNING POTENTIOMETERS
(FUNCTION SWITCH ON BAND-PASS)

Condition when Filter dial is adjusted for 180° phase shift*		Increase or decrease trim resistance as indicated below							
		HP potentiometers				LP potentiometers			
		Low end of dial		High end of dial		Low end of dial		High end of dial	
Dial Reading	Output Amplitude	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease	De-crease	In-crease
OK	LOW	R201	R211	R202	R212	R312	R302	R311	R301
		R221	R231	R222	R232	R332	R322	R331	R321
OK	HIGH	R211	R201	R212	R202	R302	R312	R301	R311
		R231	R221	R232	R222	R322	R332	R321	R331
LOW	LOW		R211,R231		R212,R232		R302,R322		R301,R321
HIGH	LOW	R201,R221		R202,R222		R312,R332		R311,R331	
LOW	HIGH		R201,R221		R202,R222		R312,R332		R311,R331
HIGH	HIGH	R211,R231		R212,R232		R302,R322		R301,R321	
LOW	OK		R201,R211 or R221,R231		R202,R212 or R222,R232		R302,R312 or R322,R332		R301,R311 or R321,R331
HIGH	OK	R201,R211 or R221,R231		R202,R212 or R222,R232		R302,R312 or R322,R332		R301,R311 or R321,R331	

*This is described in detail in the calibration of the HIGH-PASS and LOW-PASS dials of the detailed test procedure (see Table 2). The dial should agree with the input frequency when the phase shift is 180°, and the Filter output amplitude should be attenuated -3db from the nominal pass band gain when the phase shift is 180°.

SECTION 6
PARTS LIST

SCHEMATIC SYMBOL	DESCRIPTION	QTY	MFG.	MFG. PART NO.
C101	0.1μf 10% 400V Mylar	2	C-D	WMF4P1 W/FIBREGLASS WRAP
C109	0.01μf 20% 400V Paper	2	SP	67P10304
C117	8 to 60μμf Variable Capacitor	1	EL	T-50410
C119	10μμf 5% 500V Mica	1	EL	DM15C100J
C120	47μμf 5% 500V Mica	1	EL	DM15C470J
C122	39μμf 20% 500V Mica	1	EL	DM15C390M
C123	51μμf 5% 500V Mica	2	EL	DM15C510J
C124	220μμf 20% 500V Mica	1	EL	DM15C221M
C125	110μμf 5% 500V Mica	1	EL	DM15C111J
C126	39μμf 1% 500V Mica	1	EL	DM15C390F
C127	12μμf 10% 500V Mica	1	EL	DM15C120K
C128	1.5 to 20μμf Variable Capacitor	1	EL	T50210 Type 402
C129	14 to 150μμf Variable Capacitor	1	EL	T51410 Type 424
C201	51μμf 1% 500V Mica	3	EL	CM19C510F
C202	910μμf 1% 500V Mica	1	EL	CM19C911F
C203*	0.01μf 1% 100V Mylar	8	K-H	BCM-101
C204*	0.1μf 1% 100V Mylar	8	K-H	BCM-100
C205	Same as C109			
C211	120μμf 1% 500V Mica	1	EL	CM19C121F
C212*	0.001μf 1% 100V Mylar	7	K-H	BCM-102
C213	Same as C203			
C214	Same as C204			
C215	0.1μf 20% 200V Paper	4	SP	160P10404
C221	Same as C201			
C222	Same as C212			
C223	Same as C203			
C224	Same as C204			
C231	107μμf 1% 500V Mica	1	EL	CM19C107F
C232	Same as C212			

*These capacitors have a basic tolerance of 5%; they are selected and trimmed at the factory for correct calibration.

SCHEMATIC SYMBOL	DESCRIPTION				QTY	MFG.	MFG. PART NO.
C233	Same as C203						
C234	Same as C204						
C235	Same as C215						
C240	680μμf	5%	500V	Mica	1	EL	DM15C681J
C301	100μμf	1%	500V	Mica	2	EL	CM19C101F
C302	Same as C212						
C303	Same as C203						
C304	Same as C204						
C305	Same as C215						
C311	Same as C201						
C312	Same as C212						
C313	Same as C203						
C314	Same as C204						
C315	0.01μf	20%	500V	Ceramic	1	SP	29C-9B6
C321	Same as C301						
C322	Same as C212						
C323	Same as C203						
C324	Same as C204						
C331	33μμf	5%	500V	Mica	1	EL	DM15C330J
C332	Same as C212						
C333	Same as C203						
C334	Same as C204						
C402	24μμf	5%	500V	Mica	1	EL	DM15C240J
C404	0.001μf	20%	400V	Paper	1	SP	160P10204
C405A,B	200μf +50%-10%		200V	Dual Electrolytic	1	SP	D33455
C406	Same as C123						
C501	Same as C215						
C502	Same as C101						
C503A,B	40μf +50%-10%		450V	Dual Electrolytic	1	SP	17D15
C504	1μf	10%	600V	Mylar	2	C-D	MMW-6W1
C505	Same as C504						
C506	1μf	20%	400V	Oil	1	C-D	WC-4100-3
R101	1K	10%	1/2W	Carbon	4	A-B	EB-1021
R102	680K	5%	1/2W	Carbon	1	A-B	EB-6845
R104	13K (TRIM)	5%	1/2W	Carbon	1	A-B	EB-1335
R106	1.5K	5%	1/2W	Carbon	1	A-B	EB-1525

SCHEMATIC SYMBOL	DESCRIPTION				QTY	MFG.	MFG. PART NO.
R107	68K	5%	1/2W	Carbon	1	A-B	EB-6835
R109	100 ohm	20%	1/2W	Carbon	11	A-B	EB-1012
R110	1M	10%	1/2W	Carbon	2	A-B	EB-1051
R111	1K	5%	1/2W	Carbon	2	A-B	EB-1025
R112	82K	5%	1/2W	Carbon	1	A-B	EB-8235
R113	Same as R109						
R114	33K	5%	1/2W	Carbon	1	A-B	EB-3335
R117	51K(TRIM)	5%	1/2W	Carbon	1	A-B	EB-5135
R120	2K	5%	1/2W	Carbon	1	A-B	EB-2025
R122	16K	5%	1W	Carbon	1	A-B	GB-1635
R123	7.5K	5%	1/2W	Carbon	2	A-B	EB-7525
R125	560 ohm	10%	1/2W	Carbon	1	A-B	EB-5611
R126	47K	5%	1/2W	Carbon	1	A-B	EB-4735
R201	(TRIM)		1/2W	Carbon		A-B	
R202	(TRIM)		1/2W	Carbon		A-B	
R203	Under "OTHER COMPONENTS"						
R204	Same as R110						
R205	Same as R109						
R206	Same as R109						
R207	Same as R123						
R208	560 ohm	5%	1/2W	Carbon	1	A-B	EB-5615
R211	(TRIM)		1/2W	Carbon		A-B	
R212	(TRIM)		1/2W	Carbon		A-B	
R213	Under "OTHER COMPONENTS"						
R214	3.9M	5%	1/2W	Carbon	2	A-B	EB-3955
R215	6.2M	5%	1/2W	Carbon	2	A-B	EB-6255
R216	Same as R109						
R217	1.3K	5%	1/2W	Carbon	1	A-B	EB-1325
R218	22K	10%	1W	Carbon	1	A-B	GB-2231
R221	(TRIM)		1/2W	Carbon		A-B	
R222	(TRIM)		1/2W	Carbon		A-B	
R223	Under "OTHER COMPONENTS"						
R226	Same as R109						
R228	22K	5%	1W	Carbon	1	A-B	GB-2235
R231	(TRIM)		1/2W	Carbon		A-B	
R232	(TRIM)		1/2W	Carbon		A-B	
R233	Under "OTHER COMPONENTS"						
R234	Same as R214						
R235	Same as R215						

SCHEMATIC SYMBOL	DESCRIPTION				QTY	MFG.	MFG. PART NO.
R236	Same as R109						
R237	Same as R111						
R239	20K	5%	2W	Carbon	1	A-B	HB-2035
R240	24K	5%	1/2W	Carbon	1	A-B	EB-2435
R241	180K	5%	1/2W	Carbon	1	A-B	EB-1845
R301	(TRIM)		1/2W	Carbon		A-B	
R302	(TRIM)		1/2W	Carbon		A-B	
R303	Under "OTHER COMPONENTS"						
R305	9.1M	5%	1/2W	Carbon	1	A-B	EB-9155
R306	Same as R109						
R307	5.6M	5%	1/2W	Carbon	1	A-B	EB-5655
R308	TRIM (1.2K	5%	1/2W	Carbon)	1	A-B	EB-1225
R309	27K	10%	1W	Carbon	3	A-B	GB-2731
R311	(TRIM)		1/2W	Carbon		A-B	
R312	(TRIM)		1/2W	Carbon		A-B	
R313	Under "OTHER COMPONENTS"						
R316	470 ohm	10%	1/2W	Carbon	3	A-B	EB-4711
R318	Same as R309						
R321	(TRIM)		1/2W	Carbon		A-B	
R322	(TRIM)		1/2W	Carbon		A-B	
R323	Under "OTHER COMPONENTS"						
R326	Same as R316						
R328	Same as R109						
R329	Same as R309						
R331	(TRIM)		1/2W	Carbon		A-B	
R332	(TRIM)		1/2W	Carbon		A-B	
R333	Under "OTHER COMPONENTS"						
R336	Same as R316						
R338	8.2K	5%	5W	Wire-wound		IRC	5W Axial
R340	Same as R101						
R341	Same as R101						
R342	Same as R101						
R401	390 ohm	5%	1/2W	Carbon	1	A-B	EB-3915
R402	3K	5%	1/2W	Carbon	2	A-B	EB-3025
R403	Same as R402						

SCHEMATIC SYMBOL	DESCRIPTION	QTY	MFG.	MFG. PART NO.
R405	22K 10% 1/2W Carbon	1	A-B	EB-2231
R406	4.3K 5% 1/2W Carbon	1	A-B	EB-4325
R407	3.3K 5% 1/2W Carbon	1	A-B	EB-3325
R501	470K 10% 1/2W Carbon	1	A-B	EB-4741
R502	Same as R109			
R503	Same as R109			
R504	10M 5% 1/2W Carbon	1	A-B	EB-1065
R505	560K 5% 1/2W Carbon	1	A-B	EB-5645
R506	22M 10% 1/2W Carbon	1	A-B	EB-2261
R507	150K 10% 1/2W Carbon	1	A-B	EB-1541
R508	Under "OTHER COMPONENTS"			
	OTHER COMPONENTS			
F501	Fuse, 1A, Slow-Blow		BU	MDL-1
F502	Fuse, 1/2A, Slow-Blow		BU	MDL-1/2
I501	Lamp, pilot	1	GE	#51
L501	Choke, 25HY at 75MA	1	K-H	C-100-6A
R203,R213 R223,R233	Potentiometers, Part of dial tuning potentiometer assembly K-H Part No. 315-HP	4	--	--
R303,R313 R323,R333	Potentiometers, Part of dial tuning potentiometer assembly K-H Part No. 315-LP	4	--	--
R508	Potentiometer, 500 ohms, 30%, 0.2 W, Linear, WW	1	CTS	JF 7516 Type 70
S100	Switch, rotary (function sel.)	1	K-H	315-2
S200	Switch, rotary (frequency sel.)	2	K-H	S1-310
S300	Same as S200			
S501	Switch, Toggle, SPST	1	C-H	8280K16
T501	Transformer, Power	1	K-H	P-100-14B
V1	Tube, Type ECC801S	2	Tel	ECC801S
V2,V3, V4,V5	Tube, Type 12AT7/ECC81	4	Tel	ECC81
V6	Tube, Type 6X5	1	RCA	6X5
V7	Tube, Type 6AU5	1	RCA	6AU5
V8	Same as V1			
V9	Tube, Type E88CC or 6922	1	Tel	E88CC or 6922

MANUFACTURERS' CODE

Abbreviation	Manufacturer	Address
A-B	Allen-Bradley Company	Milwaukee 4, Wisconsin
BU	Bussman Mfg. Company	St. Louis, Missouri
C-D	Cornell-Dubilier Elec. Co.	South Plainfield, N. J.
C-H	Cutler-Hammer Inc.	Milwaukee, Wisconsin
CTS	Chicago Tel. Supply Corp.	Elkhart, Indiana
EL	Elmenco	Willimantic, Conn.
GE	General Electric Co.	Schenectady, New York
K-H	Krohn-Hite Corporation	Cambridge, Mass.
RCA	Radio Corp. of America	Harrison, N. J.
SP	Sprague Electric Company	North Adams, Mass.
Tel	Telefunken (c/o American Elite Inc.)	Long Island City, N. Y.

NOTES

The Manufacturer's Part Nos. listed may differ from the Part Nos. of the components found in the instrument; these substitutions, however, are direct replacements.

When ordering parts from the factory, the following information should be supplied:

1) Instrument Model Number

2) Serial Number

3) Description

4) Manufacturer

5) Part Number

All voltage and resistance values should be measured from the pins of each socket to chassis ground with a VTVM having an input resistance of no less than 10 megohms. Voltages measured with instrument operating from a 115 volt, 60 cps line. Resistances measured with power line cord disconnected.

All measurements made with FUNCTION switch set at BAND-PASS; low CUT-OFF FREQUENCY set at 50; high CUT-OFF FREQUENCY set at 50; both multiplier switches set at X100 and the front panel INPUT terminals shorted.

All resistance values in ohms, K = 1,000 ohms; M = 1,000,000 ohms. Variations of up to 20% in all readings may be expected.

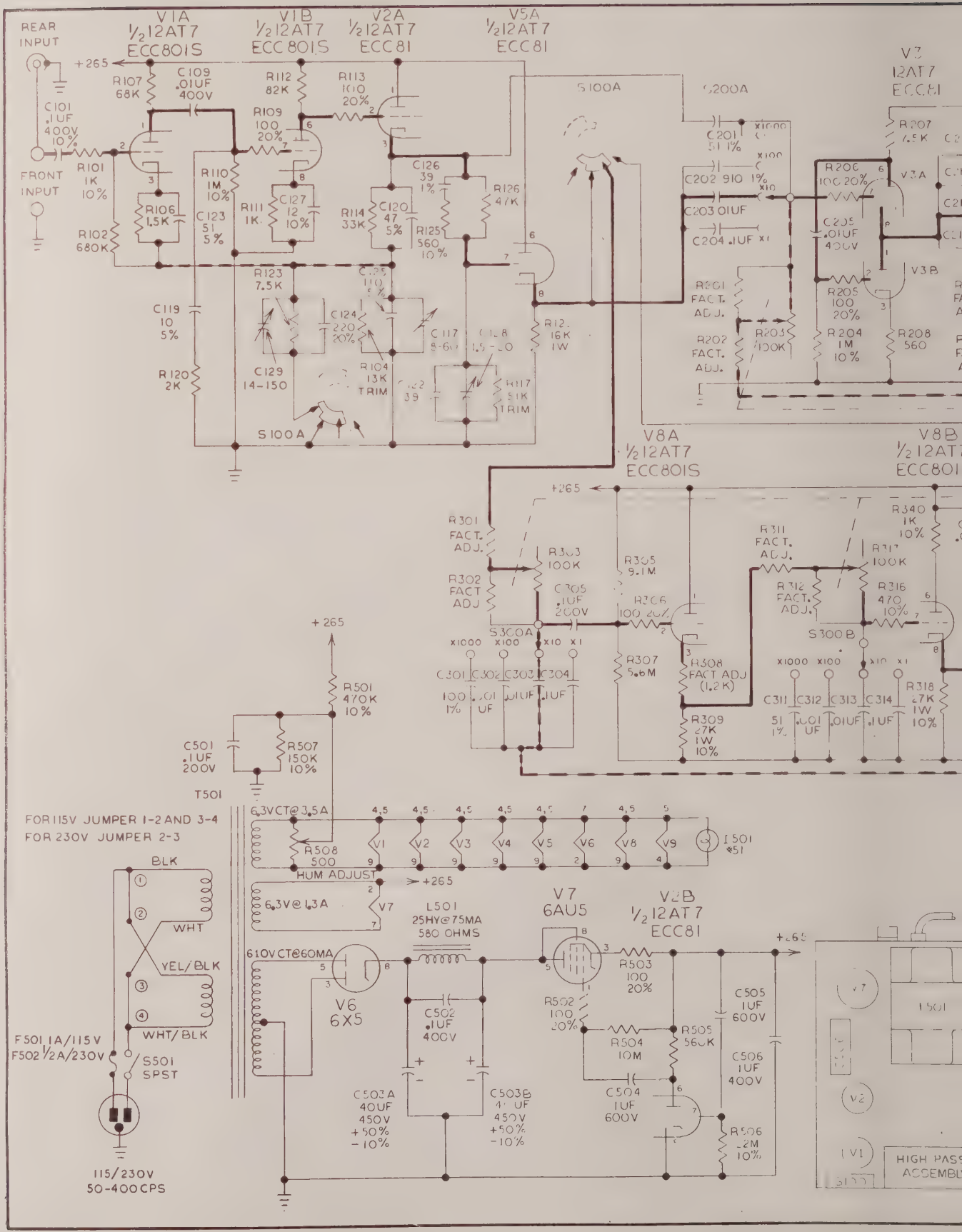
TUBE NO. & TYPE		PIN NUMBER								
		1	2	3	4	5	6	7	8	9
V1	V	175	46	49	†	†	125	0 ± 1	1.5 ± 1	†
	R	568K	700K	12K	130K	130K	582K	1M	1K	130K
V2	V	265	125	128	†	†	45	-1 ± 1	0	†
	R	500K	582K	30K	130K	130K	1M	22M	0	130K
V3	V	100	0	1	†	†	250	98	100	†
	R	> 50M	1M	560 Ω	130K	130K	500K	70K ‡	750M	130K
V4	V	265	98	100	†	†	265	98	100	†
	R	500K	2.4M	23K	130K	130K	500K	2.4M	18K	130K
V5	V	265	90	93	†	†	265	58	60	†
	R	500K	60K ‡	21K	130K	130K	500K	28K	15K	130K
V6	V	---	†	305AC	---	305AC	---	†	360	---
	R	---	130K	173 Ω	---	173 Ω	---	130K	> 50M	---
V7	V	265	6.3AC*	270	---	335	---	6.3AC*	335	---
	R	10M	---	500K	---	> 50M	---	---	> 50M	---
V8	V	265	96	100	†	†	250	96	98	†
	R	500K	3.6M	28K	130K	130K	500K	53K ‡	27K	130K
V9	V	260	95	97	†	†	250	98	100	0
	R	500K	53K ‡	27K	130K	130K	500K	55K ‡	8K	0

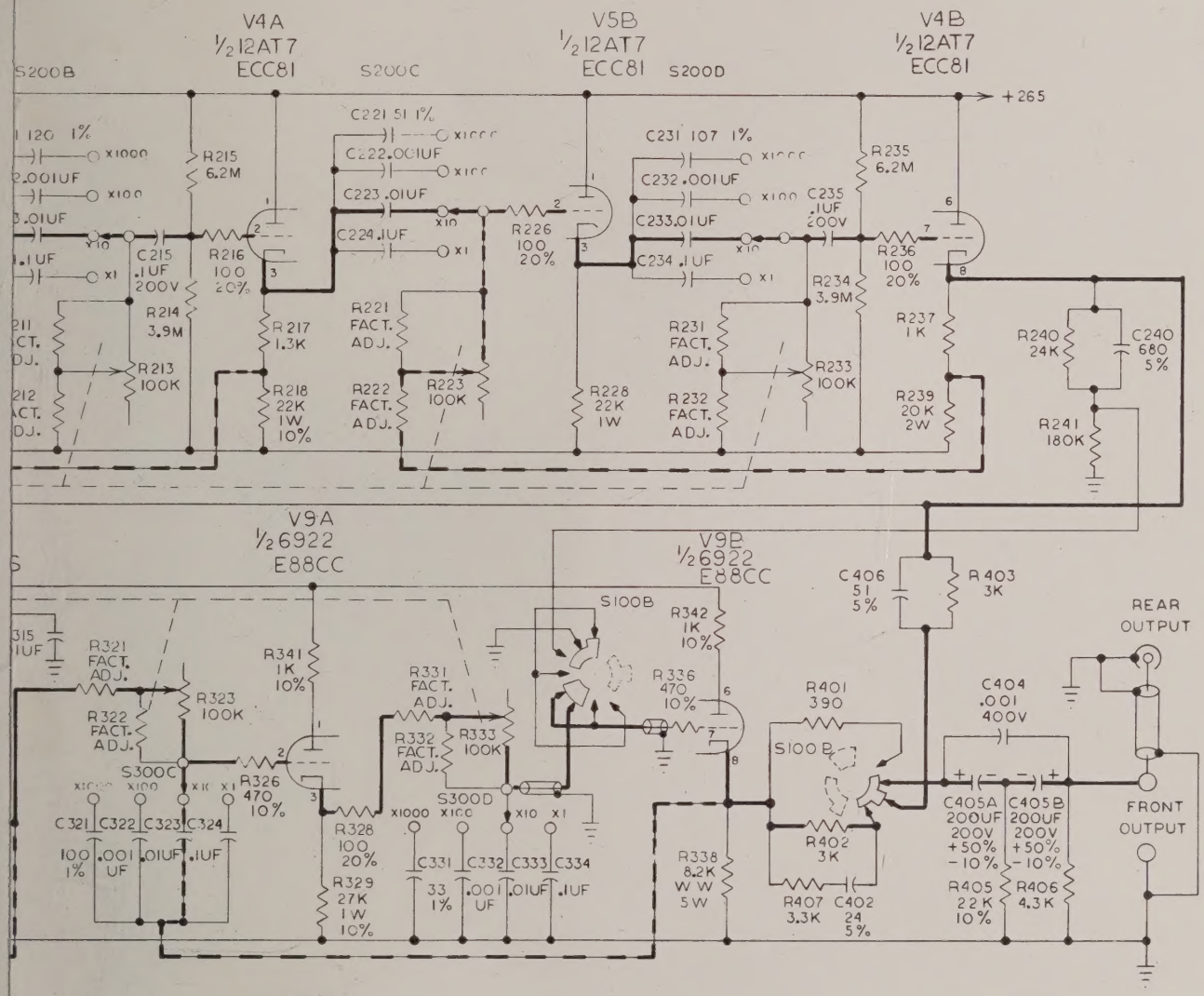
* Measured between pins 2 & 7 of V7

† Will vary between 0 and 6.3 vac depending on setting of R508

‡ May vary ± 30K

Figure 14. Schematic Diagram and Voltage/Resistance Chart


REAR INPUT
FRONT INPUT
V1A ½12AT7 ECC801S
V1B ½12AT7 ECC801S
V2A ½12AT7 ECC81
V5A ½12AT7 ECC81
V3 12AT7 ECC81
V8A ½12AT7 ECC801S
V8B ½12AT7 ECC801
+265
S100A
S200A
S300A
S300B
R107 68K
C109 .01UF 400V
R112 82K
R113 100 20%
R109 100 20%
C101 .1UF 400V 10%
R101 1K 10%
R110 1M 10%
R111 1K
C127 12 10%
C123 51 5%
R106 1.5K
R102 680K
C126 39 1%
R126 47K
R125 560 10%
C120 47 5%
R114 33K
R123 7.5K
C125 110 5%
C124 220 20%
C117 8-60
C118 1.5-10
R12. 16K 1W
C119 10 5%
R120 2K
C129 14-150
R104 13K TRIM
C122 39
R117 51K TRIM
C201 51 1%
C202 910 1%
C203 01UF
C204 .1UF
R201 FACT. ADJ.
R202 FACT. ADJ.
R203 100K
R207 7.5K
R206 100 20%
C205 .01UF 400V
R205 100 20%
R204 1M 10%
R208 560
R301 FACT. ADJ.
R302 FACT ADJ
R303 100K
C305 .1UF 200V
R305 9.1M
R306 100 20%
R307 5.6M
R308 FACT ADJ (1.2K)
R309 27K 1W 10%
R311 FACT. ADJ.
R312 FACT. ADJ.
R317 100K
R316 470 10%
R340 1K 10%
R318 27K 1W 10%
C301 100 1%
C302 .01 UF
C303 .01UF
C304 .1UF
C311 51 1%
C312 .01 UF
C313 .01UF
C314 .1UF
x1000
x100
x10
x1
R501 470K 10%
C501 .1UF 200V
R507 150K 10%
T501
FOR 115V JUMPER 1-2 AND 3-4
FOR 230V JUMPER 2-3
6.3VCT@3.5A
R508 500
HUM ADJUST
6.3V@1.3A
V1
V2
V3
V4
V5
V6
V8
V9
I501 #51
V7
L501 25HY@75MA 580 OHMS
610VCT@60MA
V6 6X5
V7 6AU5
V2B ½12AT7 ECC81
R502 100 20%
R503 100 20%
R504 10M
R505 560K
R506 2M 10%
C502 .1UF 400V
C503A 40UF 450V +50% -10%
C503B 40 UF 450V +50% -10%
C504 1UF 600V
C505 1UF 600V
C506 1UF 400V
BLK
WHT
YEL/BLK
WHT/BLK
F501 1A/115V
F502 ½A/230V
S501 SPST
115/230V 50-400CPS
HIGH PASS ASSEMBLY



NOTES:

1 S100 "FUNCTION" SHOWN IN B AND REJECT POSITION (MAX. C.W)
2 S200 CUT-OFF FREQUENCY (HIGH-PASS SECTION) SHOWN IN X10 POSITION.
3 S300 CUT-OFF FREQUENCY (LOW-PASS SECTION) SHOWN IN X10 POSITION.
4 SECONDARY VOLTAGES OF T501 MEASURED WITH 115 VAC ON PRIMARY.
5 ALL RESISTORS 1/2W 5% AND IN OHMS UNLESS OTHERWISE SPECIFIED.
6 ——— SIGNAL PATH.
7 - - - - - CORNER PEAKING FEEDBACK.
8 ALL CAPACITORS IN UUF 20% 500V UNLESS OTHERWISE SPECIFIED.
9 ALL CAPACITORS SWITCHED BY S-200 AND S-300 HAVE A BASIC TOLERANCE OF 5% (100V) OF THE VALUE SHOWN. IN ANY INSRUMENT THESE CAPACITORS ARE SELECTED TO FALL IN DECADE STEP WITHIN 2% EXCEPT ON THE TWO HIGHEST FREQUENCY BANDS WHICH ARE COMPENSATED FOR STRAY CAPACITANCES.
10 S300A S300B S300C AND S300D GANGED.
11 S100A AND S100B GANGED.
12 S200A, S200B, S200C AND S200D GANGED.

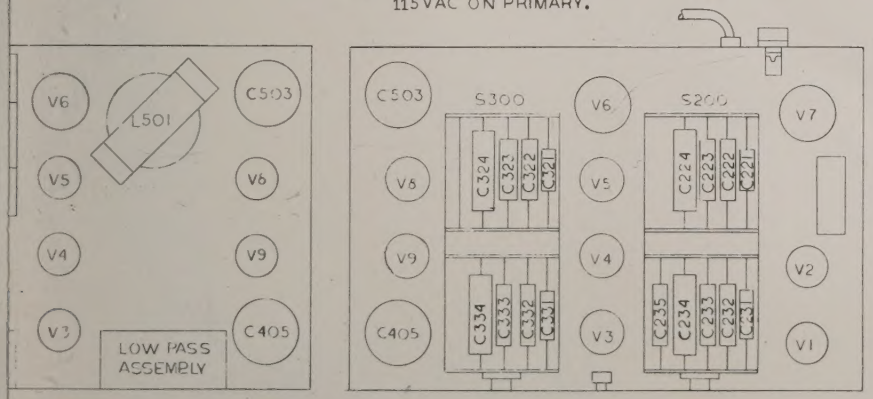


FIGURE *15
SCHEMATIC DIAGRAM
MODEL 315A(R)

Krohn-Hite

CAMBRIDGE, MASS. U.S.A.

FIGURE *1 B. MERCURIO REV 2/27/64

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge, Mass., 02139, U.S.A.

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